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THE TYPHOID FEVER EPIDEMIC AT NEW HAVEN, Conn., is reviewed as follows in the April bulletin of the Connecticut State Board of Health, in a report dated May 15, and signed by Dr. C. A. Lindsley, Secretary of the Board:

On April 3, 1901, six cases of typhoid were reported to the health officer, all in one section of the city. This was indicative of a fresh localized infection which threatened further results. An investigation was begun at once with such success that on the following day it was discovered that one reservoir, supplying the section of the city in which the fever patients resided, had become infected from a family living on its watershed. The water was immediately shut off from its consumers, and has not since been used. New cases continued to be reported daily in increasing numbers until April 9, on which day 95 were reported. From that date the numbers gradually diminished until near the end of the month, when they ceased. This termination of the outbreak was expected, as the period of incubation after the 4th of April had expired. Between April 3 and 30, 455 cases were reported at the office of the Board of Health. Some of these were reported as "suspicious," and others were prematurely stated to be typhoid, but which afterwards proved not to be. A careful inquiry is being made to determine as close as possible the number of true cases.

The total deaths at this date, May 12, have been 54, nearly 12% of the cases reported. The reservoir has been emptied completely and the pipes flushed with water from other sources. The reservoir has been refilled and will stand, by order of the Board of Health, unused a month and then drawn off, and may again be refilled for renewed use.

The New Haven Water Co., under its present management, has been and are making many efforts to protect the water from contamination. Many hundred acres of watershed have been purchased and cleared of all sources of pollution. The large extent of watershed contributing to the supply is constantly patrolled. The town health officers are paid for reporting to the company every case of typhoid fever occurring near any tributary to the reservoir.

Notwithstanding all the above precautions, this disastrous accident has occurred, and illustrates more emphatically than any argument the danger of disposing of typhoid excretions without previous disinfection.

THE SLOW-SAND FILTRATION PLANT FOR TOKYO, Japan, built in connection with the new water-works, includes 14 filter beds with a total area of about 14 acres. The water is taken from the Tawa River. The new supply, according to the "Gesundheits Ingenieur," will cost over $3,000,000.

THE FIRST IRON RAILWAY BRIDGE to be constructed anywhere in the world has recently been torn down and replaced by a new structure. This interesting bridge was built in 1823 on the Stockton & Darlington Ry., England, and crossed the River Gaundless, a tributary of the Wear at West Auckland, then termed St Helens. It was composed entirely of cast-iron, and is generally believed to have been built by Mr. George Stephenson, the Chief Engineer of the Stockton & Darlington Ry.

THE VENTILATION OF THE ELKHORN TUNNEL on the Norfolk & Western R. R., is described in an article by Mr. Charles S. Churchill, Engineer Maintenance of Way, in the "Railroad Gazette" of May 10, 1901. The Elkhorn tunnel is about 3,000 ft. long, and it has an ascending grade towards the east of 1.4%. A large portion of the traffic through the tunnel from west to east consists of coal trains, to haul which against the adverse grade requires the use of two or three engines, and the amount of smoke and gas emitted by each train is necessarily very great and has long caused inconvenience in operating the tunnel. After careful consideration it was decided to instal a system of ventilation modeled on that used at the Pracchia tunnel in Italy, which consists in forcing air in at one end of the tunnel by an injector formed by enclosing the area between the outline of a train and the walls of the tunnel, as a passagway through which the air is forced. As carried out at the Elkhorn tunnel, an air chamber was formed in the sidewalls and roof of the tunnel, which gradually tapered from the entrance to the blast opening, and into this chamber air is forced by two 14-ft. diameter fans capable of delivering each 165,558 cu. ft. of air per minute at 1 ounce pressure. As constructed the arrangement acts similarly to an injector, and repeated tests have shown its ability to keep the tunnel practically clear of smoke and gas even while the trains are in transit. The apparatus as installed has been patented by Mr. Churchill and Mr. C. E. Wentworth, Bridge Engineer, Norfolk & Western R. R.

THE STEEL RAILWAY VIADUCT across the Des Moines River, which has been under construction for some time by the Chicago & Northwestern Ry., on its new double-track cut-off between Boone and Ogden, Iowa, was opened to traffic on May 19. The new bridge consists of a 300-ft. truss span across the main channel of the river and of a series of plate girder and lattice girder spans carried by steel framework towers for the remainder of its length of 2,685 ft. At its highest point the viaduct is 185 ft. high to the base of the rail, and it is 27 ft. wide and carries two lines of railway track. Altogether 6,100 tons of steel were consumed in the bridge, of which 5,680 tons were in the superstructure.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment caused by the spreading of the rails at a sharp curve near Hazlehurst, Miss., on the Illinois Central Ry., on May 13. One man was killed and two others were badly injured and the locomotive and three cars were wrecked.

THE BATTLESHIP "OHIO" was launched on May 18 at the Union Iron Works, San Francisco, Cal., in the presence of President McKinley. This vessel is a sister ship to the "Maine," now building at the Cramp's Shipyard, in Philadelphia, and to the "Missouri," now building at Newport News. She is built of steel, unsheathed, and is 388 ft. long on the load water line, 72 ft. 2½ ins. extreme beam, has a mean draft of 23 ft. 6 ins., and a displacement of 12,230 tons. Abreast of the boiler and engines the side armor belt extends from 3 ft. 6 ins. above to 4 ft. below the water line; is 11 ins. thick for a depth of 4 ft. 6 ins. and tapers to 7½ ins. thick at the bottom of the belt. The casemate armor above this belt is 6 ins. thick, ending in diagonal cross armor 9 ins. thick. The protective deck, below the water line, is 2¾ ins. thick on the flat and 3 ins. and 4 ins. thick on the forward and aft slopes. Coffer dams, filled with corn-pith cellulose, extend nearly the length of the ship on the berth deck. The main battery of the "Ohio" consists of four 12-in. breech-loading rifles, in two balanced turrets, and sixteen 6-in. rapid-fire guns. Ten of these latter guns are in the casemate; two are in armored sponsons forward, on the berth deck, and four are on the upper deck, with a fore and aft fire for each pair as well as a broadside fire. The secondard battery includes six 3-in. rapid-fire, eight 6-pdr. rapid-fire, six 1-pdr. rapid-fire, two Colts and two 3-in. rapid-fire field guns. The "Ohio" has two submerged torpedo tubes, about 50 ft. from the bow and 10 ft. 6 ins. below the water line, being the first American warship so equipped. The two military masts are fitted with the usual signal yards, tops and topmasts. The forward conning tower is protected by 10-in. armor, and the aft tower with 6-in. armor; and the pipes, wires, etc., connecting the forward tower with the protected deck and important stations below are protected by a steel tube 12 ins. in inside diameter and 7 ins. thick. Bilge keels are fitted to the hull, the forward keel being 87 ft. long and the after keel 75 ft. long. There are four dynamo rooms, each fitted with two generating sets for providing power for lighting the ship, turning the turrets, operating hoists, etc. The normal coal supply is 1,000 tons, and the bunker capacity is 2,000 tons. The water-tube boilers, of the Thorneycroft type, are placed in four water-tight compartments, and these operate engines developing 16,000 HP. at 18 knots speed. The "Ohio" and her mates were authorized by Congress on May 4, 1898, and the keel was laid April 12, 1899. The contract price for hull and machinery was $2,899,000. She will carry 35 officers and 511 men.

THE NORTH GERMAN LLOYD STEAMER "Kronprinz Wilhelm" was recently launched at the Vulcan Yards, at Stettin, Germany. This ship is 663 ft. 4 ins. long over all, 66 ft. beam, 43 ft. molded depth, 21,300 tons displacement, loaded, and 14,800 tons registered. Her maximum bunker capacity is 4,550 tons; the engines develop 30,000 HP., and her contract speed is 23 knots. There is a double bottom throughout the length of the ship, divided into 27 water-tight compartments; and 17 very strong cross bulkheads and one longitudinal bulkhead divide the hull into 36 water-tight compartments. Electrical connections centering in the chart rooms show what bulkhead doors are open or shut. There will be two quadruple expansion engines, supplied with steam from 12 double and four single boilers. Her carrying capacity is equal to 604 first-class, 349 second-class passengers and 702 steerage, in addition to a crew of 522 persons.

THE HEIGHT OF WAVES at Peterhead, North Britain, during the severe storm of Feb. 15 and 16, 1900, is discussed in a paper recently read before the Institution of Civil Engineers of Great Britain by Mr. William Shield. The velocity of the wind during the storm is considered to have fluctuated between 50 and 80 miles per hour. The method of measuring the waves and the heights attained by them are described as follows:

On the afternoon of the 16th, when the wind had somewhat abated, sights along the breakwater were taken with the view of ascertaining the height of the waves as they ran into the bay, between the breakwater end and the opposite shore (Keith Inch). The depth of water along the line of sight was about 10 fathoms to 10½ fathoms. The sights, which were 6 ft. 6 ins. high and 120 ft. apart, were on the coping of the breakwater, the level of which is 22 ft. above low-water of spring tides. At the time of observation the tide-gage registered 9 ft.; the line of sight was therefore 19 ft. 6 ins. above the still-water level. The waves were irregular in respect of height and length as well as of period, but wave after wave passed, having its crest, quite unbroken, at least 3 ft. above the line of sight, and therefore fully 22 ft. 6 ins. above the still-water level. The periods of the waves varied between about 13 secs. and 17 secs., and their lengths were probably between 500 ft. and 700 ft., but the author had no means of accurately ascertaining this. Assuming the troughs of the waves to have been as far below the still-water level as their crests were above it, the height of the waves would have been 45 ft.; but the apparent flatness of the trough curve, compared with that of the crest, seemed to indicate that the height of the crest above, and the depth of the trough below the still-water level were not identical. There can be little doubt that the crests of the waves were to some extent raised by the friction of the sea-bed, and since the volume of water above the still-water level must correspond with that of the trough below it, it is probable that the height of the waves, trough to crest, closely approximated to 40 ft.

THE SAVANNAH HARBOR CONTRACTORS, indicted in December, 1899, for conspiracy with ex-Captain Carter to defraud the Government, are at last to be removed to Georgia for trial. Judge Brown, in the U. S. District Court, on May 15, issued the order for the removal, and in his decision said:

The defendants have given a great deal of evidence tending to show that their contracts were fairly obtained, their work well and honestly done and that the government has not been defrauded of a single dollar. The government, on the other hand, has given evidence tending to a contrary conclusion; and it has shown beyond question that Captain Carter, the employe of the government and the engineer in immediate charge of the work on the government's behalf, had for several years immediately preceding the contracts referred to in this indictment received from the contractors continuously, through his father-in-law, in many divisions of profits, one-third of the final net proceeds of each contract remaining for division among the chief contractors, and that this one-third amounted in the aggregate to over $7,000. This, it is claimed, gives significance and meaning to many other facts in evidence showing a fraudulent and illegal combination between the defendants and Captain Carter to benefit themselves at the expense of the government, and to procure the allowance and payment of excessive and fraudulent bills by means of contracts fraudulently procured.

The lawyer who is defending the indicted parties is quoted as saying that applications will be made for writs of habeas corpus to further delay the removal of the indicted parties to Georgia for trial.

A 120-TON DERRICK CRANE has recently been erected at the works of William Doxford & Sons, Ltd., of Sunderland, England. At 50 ft. radius the deadweight lift of the crane is 120 tons; at 80 ft. radius 70 tons, and at 100 ft. radius 30 tons. At the 50 ft. radius the jib will swing through an arc of 227°; at the 100 ft. radius, through an arc of 240°. The structure of the crane is of box girder form, and is built up of steel plates. It stands on a block of concrete, with two separate blocks for the back legs. On the top of the concrete foundation is a cast-iron pivot, upon which the weight of the crane is carried through a brass-lined bearing. To this pivot a large circular rack is bolted to turn the crane round. The engines are arranged in the body of the crane tower. The two winding drums are set one above the other, the lower one being for the heavy lift, from 50 tons to 100 tons; the upper drum is divided into two parts, each driven by its own engine. One-half of the drum is for the light lift, whilst the other is for luffing the jib. These three drums are driven by worm and wormwheel. These wheels have cast-iron centers and phosphor-bronze rims, with the teeth cut out of the solid. The turning engine drives the pinion, which gears in the circular track already mentioned by a double train of worm gearing. The stop valves, reversing levers, and brakes, are all arranged in a cabin at the back of the crane tower, in such a way that one man can operate them all. The reverse links of the engines are thrown over by hydraulic rams. The power for this purpose is supplied by a small duplex pump, which works a small accumulator with automatic shut-off gear. The light lift pulley hangs at the extreme end of the crane jib, and the heavy crane lift is about a quarter of the length of the jib from its end. Wire ropes are used. The swivels of the hoisting shackles are carried on small rams inside cylinders filled with oil.

HIGHWAY BRIDGE OF 406-FT. SPAN; HAMILTON, O.

(With two-page plate.)

Highway bridges of 400-ft. span are sufficiently unusual to warrant more than passing mention, and we illustrate this week a bridge of 406-ft. span, c. to c. of end pins, which was built at Hamilton, O., in 1899. The bridge, which is known as the Columbia bridge, spans the Miami River at Columbia and Chestnut Sts., and takes the place of an old wooden structure which was washed out some years ago. The bridge is not only notable on account of its length, but also in many points of its construction. The flooring is one of the important points, the roadway having asphalt blocks on concrete laid upon a buckle plate floor, while the two sidewalks are of concrete slabs built in place. The trusses are 50 ft. deep at the middle, spaced 26 ft. 6 ins. c. to c., the roadway being 22 ft. wide in the clear, and the sidewalks (supported on cantilever brackets) 6 ft. wide in the clear. The bridge was designed and built by the Wabash Bridge & Iron Works, of Wabash, Ind., and we are indebted to Mr. C. E. Howe, Chief Engineer of the firm, for drawings and photographs of the structure. The work was done subject to the supervision of Mr. L. A. Dillon, County Engineer and City Civil Engineer, of Hamilton; and all inspection was done by the Osborn Engineering Co., of Cleveland, O. Figs. 1 and 2 are side and end elevations of the structure.

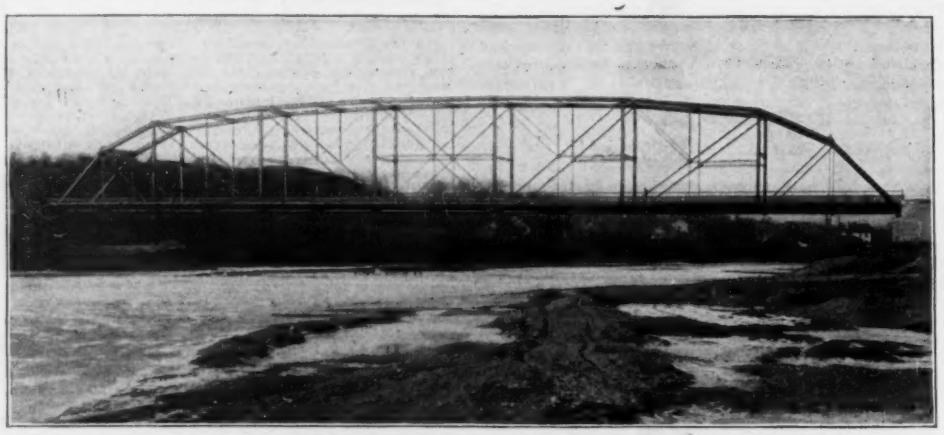


FIG. 1. GENERAL VIEW OF 406-FT. HIGHWAY BRIDGE; HAMILTON, O.
Wabash Bridge & Iron Works, Builders.

The structure is calculated for a dead load of 5,000 lbs. per lin. ft. of span; live load, 2,720 lbs. per lin. ft. of span, or 80 lbs. per sq. ft.; wind pressure, 150 lbs. per ft. dead load on top chord, 150 lbs. live load, and 150 lbs. dead load per ft. of bottom chord. The floor system is calculated for a 20-ton roller on two axles 12 ft. apart, or a 16-ton electric car. All the material is of medium steel, of 60,000 to 70,000 lbs. ultimate tensile strength. The total weight of steel in the structure is about 1,300,000 lbs. The strain sheet is given in Fig. 3.

The trusses are divided into seven main panels, 58 ft. c. to c. of pins, with floor beams 29 ft. c. to c., the alternate floor beams being carried by hangers. The top lateral struts are also 29 ft. c. to c. The height at the portals is 29 ft., with a clear headway of 20 ft., and the truss depth increases to 42 ft. at the first main panel point, 48 ft. at the second, and 50 ft. at the third panel point. Longitudinal and transverse braces are fitted between the posts, and these braces are built-up latticed members. The top chords and the batter posts are of box section, with three webs 20 ins. deep, a cover plate 28 ins. wide, and eight lines of flange angles. Each post is composed of a pair of channels, set back to back and connected by lacing bars $\frac{5}{8} \times 2\frac{1}{4}$ ins., 1 ft. 10 13-16 ins. c. to c. These are riveted by $\frac{3}{4}$-in. rivets; all other rivets in the posts being $\frac{7}{8}$-in. diameter. The bottom chords and main diagonals are built up of eye-bars, and the hangers for the intermediate floor beams are also eye-bars. The verticals or substruts at intermediate points are composed of four angle irons with lacing bars $\frac{1}{4} \times 1\frac{3}{4}$ ins., while the diagonals are eye-bars. The counters are eye-bars, set up by turnbuckles. The sway bracing and the top and bottom diagonal lateral bracing consists of round rods with loop ends, set up by turnbuckles. The top lateral struts have top and bottom chords composed of pairs of steel angles with the ends of web lattice bars riveted between them. The pins for the top lateral rods are carried by horizontal connection plates riveted to the chord and strut, while those of the bottom lateral rods are carried by vertical connection plates having the ends bent in the direction of the rods. The details of construction are shown by the general drawing of the trusses in Fig. 4.

The floor system is composed of plate girders $45\frac{1}{2}$ ins. deep, those occurring at the panel points being riveted to the posts, while the intermediate floor beams have end plates carrying the pins for the eye-bar hangers. The tops of the floor beams are cambered $3\frac{1}{2}$ ins. to give the required crown for the roadway. Between these beams are two plate girders (at the sides) and five lines of 20-in. I-beam stringers supported on brackets, and having their tops flush with the top of the beams. These carry a deck of 5-16-in. steel buckle plates, 3 ft. $7\frac{1}{2}$ ins. wide; these are 8 ft. 6 ins. long for the end panels (Fig. 5), and 14 ft. $3\frac{1}{8}$ ins. for the intermediate panels. These plates are laid with the dish downwards, and on them is a layer of concrete $2\frac{1}{2}$ ins. thick over the stringers. A bed of sand 1 in. thick is laid on the concrete, and upon this are laid the 3-in. asphalt paving blocks. The wheel guards or fenders are formed by the plate girder stringers, and 5-16-in. cover plates fill in the space between the roadway and sidewalk, being cut away for the various members which pass through. The buckle plates were relied upon to transmit wind load, the lower diagonal rods being hardly necessary, except for safety and convenience in erection, although they were calculated to take their proportion of the wind load.

The sidewalks are carried by triangular cantilever brackets. Those at the main panel points are riveted to the posts, while those at the intermediate points are riveted to the floor beam end plates, which carry the hanger pins. The end floor beams are continued to form the cantilevers, but have the webs cut away for the bottom chords. Upon these cantilever beams are two lines of plate girders, with 6-in. transverse I-beams secured to their webs, these beams being 7 ft. 3 ins. apart. These carry 4-in. I-beam joists or stringers, upon which is the self-supporting concrete pavement 3 ins. thick over the stringers. This concrete is composed of 1 part Alsen's Portland cement to 2½ parts sand and 5 parts gravel, with a finishing coat of sand and cement 1 to 1. Fig. 6 shows the temporary wooden staging used in laying the concrete. Wooden joists 2 × 6 ins. were placed between the transverse I-beams, and supported the outer ends of strips 2 × 4 ins., the inner ends of which rested on the flanges of the 4-in. I-beam stringers. Upon these was placed the 1-in. plank sheeting. When the concrete had set, the wooden joists were knocked away, allowing the strips and sheeting to be removed. These sidewalks have been in use about a year, and are reported to be in as good condition as when they were laid.

At the fixed end of the bridge, the $\frac{3}{4}$-in. base plate of the shoe rests upon 12 I-beams 8 ins. high, with packing blocks between the webs, and held together by two $\frac{3}{4}$-in. rods through each set of blocks. The ends of the I-beams are cut at an angle of 45°. Under the beams is a 1-in. bed-plate 50 ins. wide and 5 ft. 6 ins. long.

At the expansion end of the bridge, Fig. 7, the shoe rests upon nine rollers, 6 11-16 ins. diameter, with $1\frac{1}{2}$-in. bearing plates above and below, the plates being 52 ins. wide and 5 ft. 6 ins. long. The ends of the rollers are turned to 1-in. diameter and are carried in 1-in. spacing bars 3 ins. deep, while at the middle they are turned to a diameter of 5 3-16 ins.

The ornamental hand railing is shown in Fig. 8. The top rail is of 3-in. gas-pipe, and the bottom section is composed of two chords, each made up of two angles $3\text{-}16 \times 1\frac{1}{2} \times 1\frac{1}{2}$ ins., between which are riveted diagonal lattice bars $3\text{-}16 \times 2\frac{1}{2}$ ins. The middle portion is composed of a scroll design built up of bars $3\text{-}16 \times 1\frac{1}{2}$ ins. This railing is in panel lengths of 14 ft. 6 ins., the ends of the panels being riveted to posts of bars $\frac{5}{8} \times 1\frac{1}{2}$ ins., bolted to the floor system, and having angle iron braces. Fig. 9 shows the ornamental cresting over the portals, which is built up mainly of bars $\frac{1}{4} \times 2$ ins.

FIG. 2. END VIEW.

The inside of chords was given two full coats of paint at the shop, and the outside of chords, posts, floor beams, etc., one coat, after inspection. The

field painting consisted of two coats, the finishing coat being red in color. Red mineral paint was used for all the work.

The abutments are very small and simple, and consist of main walls and short wing walls of stone masonry. These were built by Louthan & Shields, of Hamilton, O.

The falsework consisted of thirteen pile bents; six of these had two piles at each end (3 ft. 4 ins. c. to c.), and a fifth in the middle; the others had three piles. Each bent had a cap 12 × 12 ins., 36 ft. long; a horizontal brace of planks 3 × 10 ins., and two diagonal sway bracing planks 3 × 10 ins. The three middle bents were braced by longitudinal diagonal bracing of planks 3 × 10 ins. Across the caps over each inner line of double piles, was a line of timbers 10 × 12 ins., 32 ft. long, overlapping on the caps, the outer ones being 26 ft. 6 ins apart in the clear. Over the outer piles was a traveler track composed of a line of 20-in. I-beams spliced together by fish plates. This track was 3 ft. 4 ins. from the longitudinal timbers. This construction is shown in Fig. 10. The bottom in which the piles were driven consisted partly of gravel and partly of a variable material composed of gravel, sand and mud.

The erection of the bridge was done by the aid of a tall traveler running on the falsework tracks.

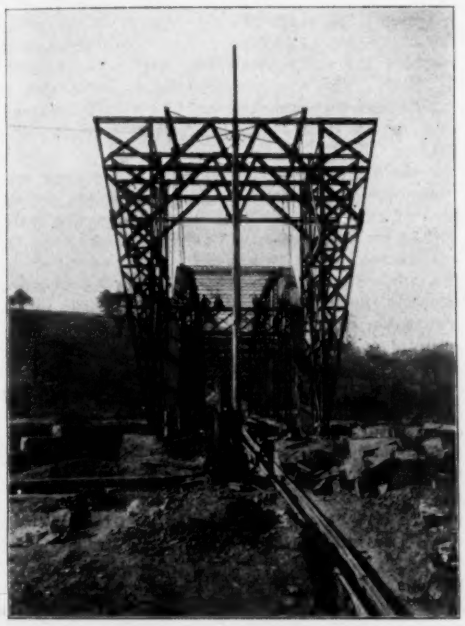


Fig. 12. View of Traveler.

This traveler was 58 ft. long, covering one entire panel, and consisted of three framed bents, 63 ft. high from the shoe to the top chord, and 53 ft. 2 ins. wide at the top. The construction is shown in Fig. 11, while Fig. 12 is an end view showing the traveler and the completed bridge. The three trussed bents were connected and braced longitudinally by horizontal and diagonal timbers between the legs, and by angle iron lateral bracing on top. Each leg of each bent rested on a shoe with a bearing surface of 16 × 14 ins. from the leg and the bottom longitudinal timbers. The shoe had a 2½-in. shaft, with a double-flanged roller having a convex tread. The diameter was 10¾ ins. at the center of the tread, and 14 ins. over the flanges, the width at the hub being 9½ ins. The shoe and roller are shown in Fig. 13. The hoisting for the traveler tackles was done by a 15-HP. engine with a vertical boiler, and a similar engine with a gin pole was used for handling the masonry.

The erection was commenced at the middle and finished to the fixed end, when the traveler was moved back towards the sliding end. Mr. C. E. Howe, Chief Engineer of the bridge company, arranged a pulling-jack for setting the pins in place by the help of a 2½-in. square threaded screw. He states that while they were able to set the pins in in this way, it was found to be more satisfactory to do it by "dinging"(as the men called it) with a battering-ram. This consisted of a heavy bar of iron swung by a line from a high point on the traveler. All work was field-riveted, except the buckle plates and the 42-in. plate between roadway and sidewalks. These were bolted with ⅝-in. bolts, spaced 6 ins. apart. Material was brought to the traveler by push cars on a track made with the sidewalk girders, which served as convenient girder rails. The cars were pulled up the grade at the end of the bridge by a line run out from the hoisting engine used for the masonry work. For hoisting the chord sections, ⅝-in. round wire cables were used, with double blocks. All the other lines were of manila rope.

THE NEW WATER SUPPLY OF CINCINNATI, O.

Owing to the increasingly bad quality of the water supply of Cincinnati, which is drawn from the Ohio River at a point near the city where it is subject to serious contamination by sewage and waste, a new supply system was decided upon a few years ago, and the works are now well under way. The construction of these works is under the control of a board of trustees, independent of the water department of the municipal government. The plant will include a complete system for sedimentation and filtration of the water, and extensive investigations and experiments have been made in regard to this part of the plant.

The supply will be taken from the Ohio River as at present, but at a point about seven miles above the city, where the water is of better quality, though still so badly polluted as to require a purifying treatment, and where it also contains a large proportion of sediment. This intake is at the village of California, and here also the settling basins and filters will be established. The general scheme, the bacterial experiments and the intake works of the new water supply system were described and illustrated in our issues of Dec. 8, 1898, and April 26, 1900.

INTAKE AND EASTERN PUMPING STATION.—The intake is a masonry crib or pier in the deep water of the river channel, which is near the Kentucky shore at this point, the depth at low water being about 20 ft. at the pier. A light truss bridge of one span extends from the pier to the Kentucky shore. In the pier are openings fitted with gates for admitting water at different stages of the river, and the water flows down a 10-ft. shaft to a 7-ft. tunnel extending under the bed of the river to the Ohio side. The tunnel ends at another shaft, which reaches the surface near the edge of the river bank. The shaft is 8 ft. in diameter (inside the brick lining), where it passes up through the rock, but above the rock it has a 10-ft. steel shell, which extends up to the level of the floor of the pump house. Surrounding the top of this steel shaft is a pump-well, 98 ft. diameter and 85 ft. deep, which is founded on a timber caisson 127 ft. in diameter, sunk by the pneumatic system, as described in Engineering News, April 26, 1900.

The intake pier and the pump-well shaft have gates which will be operated by electric or pneumatic hoists. For pumping out the river tunnel to allow of inspection, repairs and the removal of silt deposit, there will be at the eastern, or California, pumping station a deep well-pump, which is being installed by the Hendrick Mfg. Co., of Carbondale, Pa. The pump is of the propeller type, patented by P. K. Wood, of Los Angeles, Cal. It will be operated by an electric motor on a platform inside the shaft, near the level of the floor of the pump house, and will have a guaranteed discharge capacity of 1,000 gallons per minute for 24 hours continuous service. This pump is experimental, and the contract includes the necessary motors and generating plant, with a provision for the removal of the pump in case it proves unsatisfactory.

Over the well will be a pump house. Coal may be brought by river barges and hauled up an incline, or by railway cars direct to the boiler house on a spur track from a branch line which runs from the main line of the Cincinnati, Georgetown & Portsmouth Ry. This branch, described in our issue of April 26, 1900, was built by the water-works trustees for bringing in supplies and material during construction and will probably be extended later on as a regular branch of that road, which now operates a train service over it.

Within the pump-well above mentioned there will be installed four vertical triple-expansion pumping engines, each of 30,000,000 gallons daily capacity, the four 48-in. discharge pipes delivering into two lines of 60-in. cast-iron pipe, each about 4,000 ft. long, which will discharge the water into the settling basins through a masonry weir. The embankment which will carry the lower part of the pipe line has already been built.

PURIFICATION PLANT.—From the intake the water will be pumped directly to the purification plant, which will include both sedimentation and filtration. The water will first enter the settling basins, of which there will be two, used alternately, and of such capacity as to give five or six days' storage for settlement. No. 1 has an area of 21.75 acres, with an available storage capacity of 158,300,000 gallons and a total capacity of 183,700,000 gallons. No. 2 has an area of 25.75 acres, with capacities of 187,000,000 and 222,500,000 gallons. Active work on the grading is now in progress. The basins will be at an elevation of about 145 ft. above the river. In excavation, the bottom will be composed of 2 ft. of selected earth, 12 ins. of broken stone (at upper part of side slope only), 6 ins. of concrete, two layers of asphalt and burlap, and a top course of one layer of brick. Around the basins will be a 20-ft. roadway, about two miles in length. The road will be sloped away from the basin, and have a 6-in. curb on that side, so as to prevent surface drainage into the basin. The drainage will be collected by a system of open and pipe drains and

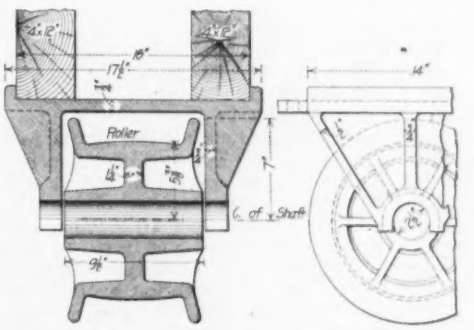


Fig. 13. Shoe and Roller of Traveler.

discharged into the Miami River. Along the roadway will be a line of 8-in. cast-iron pipe with hydrants at intervals. Large numbers of men are employed on the grading for these basins and on other work, and the water-works trustees have established a special police force, with police station on the ground, to check all disturbances.

For each basin, the two 60-in. effluent mains and the 30-in. pipe for draining the basin are laid in a 16-ft. arched tunnel under the dam. The two 60-in. mains are carried by I-beams built into the side walls, while the 30-in. drain pipe is below them, supported on stone blocks on the invert. The delivery end of each supply main from the weir has a 6-ft. elbow turned upward and placed at the head of an aerator, consisting of a masonry channel 18 ft. wide, with steps forming a cascade. The effluent mains are connected to a floating inlet in each basin. The inlet consists of two 48-in. hinged inclined pipes, with a float at the top, which keeps the mouth just below the water level. The effluent pipes will deliver the water to a mechanical filter plant, from which it will pass to a clear water reservoir, and will be delivered thence through a long tunnel to the western pumping station in the city.

The experimental plant and the investigations conducted by Mr. George W. Fuller, Assoc. M. Am. Soc. C. E., were described in our issue of Dec. 8, 1898, and his exhaustive report on the subject was reviewed editorially in our issue of March 9, 1899. Mr. Fuller recommended mechanical filtration. In November, 1899, the trustees in charge of the new works instructed "the chief engineer and his associate engineers" to report on the most feasible plan of purification. On Jan. 12, 1900, the report was submitted, signed by Mr. Gustave Bouscaren, Chief Engineer, and Messrs.

George H. Benzenberg and Charles Hermany, Consulting Engineers. The engineers reviewed the relative merits of slow sand and mechanical filtration and coincided with Mr. Fuller's conclusions in favor of mechanical filtration. Subsequently the recommendations of the engineers were approved by the trustees and mechanical filtration was thus adopted. The engineers' report is printed in the fourth annual report of the Board of Trustees, Commissioners of Water-Works.

LAND TUNNEL.—There will be a tunnel about 4 miles long from the shaft at the filtration works to the new city pumping station, which will be 2½ miles further up the river than the present station (to be abandoned). The tunnel will be 7 ft. diameter inside the brick lining, and the bottom will be about 130 ft. below the surface, with about 20 ft. of limestone and shale rock and 100 ft. of alluvial soil over the roof. Borings were made 1,000 ft. apart and tests made as to the impermeability of the rock at the level of the tunnel. For this purpose pipes were let into the holes and the openings sealed by a rubber sleeve between the rock and the pipe. The holes were then pumped out, through the pipes, and any water found by subsequent pumping represented seepage, with due allowance for occasional defective sealing of the holes. Of all the holes thus tested, 80% were dry and 20% had water, 25% of these latter being very wet. The top of the tunnel is about 75 ft. below the lowest water level in the river, and the minimum suction head, corresponding to a delivery of 100,000,000 gallons in 24 hours, will be about 5 ft.

The tunnel is to be driven from five shafts. No. 1 (at the city end) is 133 ft. deep and is being lined with brick through the rock and with a riveted steel shell (with inside brick lining) above the rock; No. 2 is completed and headings are being driven in both directions from its bottom. At the beginning of April, shaft No. 3 was down to rock; No. 4 had not yet reached the rock and No. 5 (at the filter works) had not been started. Each shaft has a cast-iron curb or shoe, and a steel shell 12 ft. in diameter, the shoe being weighted by building up a brick lining wall, which gives an inside diameter of 10 ft. In shaft No. 1 an air lock had to be installed to enable the work to be carried through the wet section. The pressure carried varies with the stage of water in the river, the highest pressure used being 35 lbs. per sq. in. The rock consists of alternate layers of limestone and blue shale; the latter is hard but disintegrates after exposure. The strata are nearly horizontal, and in many parts of the headings the roof is perfectly flat. Gas pockets are occasionally met with. The tunnel is built partly under a purchased right of way and partly under the streets and the main road to the village of California. Between each pair of shafts there are two angles, making the alinement difficult, so that great care has to be taken in transferring the line down the shafts. Large plumb-bobs are used and are set in glass jars of glycerine and water, provided with caps to prevent water dropping in and causing vibration.

No timbering is required, but the lining is kept up as near as practicable to the face, on account of the disintegration of the shale. The lining consists of two rings of specially made shale brick, which is very hard; as the cement mortar does not adhere well to the smooth surface, two grooves are formed in the sides to hold a mortar key. The mortar joints are neatly smothed off in the interior of the lining. All spaces between the outside of the lining and the excavation are filled with concrete, well rammed in. Rand and Ingersoll drills are used, and about 15 to 17 holes are drilled in the face. The first six form a central cone, which is blown out first, thus facilitating the blowing out of the sides. The explosive is a 40% dynamite, with a charge of about 3 lbs. to each hole. The work is done in two 12-hour shifts, and where compressed air is employed the men work for three hours and then go out for three hours.

This will be a gravity conduit, the tunnel having a grade of 1 in 2,000 from the clear water shaft to the shaft of the city pumping station. A steel surface conduit was first proposed, but investigation showed that a tunnel in the rock would cost less and be more advantageous in many ways. As the city supply will be pumped directly from the tunnel to the distribution system, with no reservoir to equalize the supply, there will be little opportunity for inspection or cleaning of the tunnel, but as the water will have been purified by settlement and filtration there will be very little deposit of silt in the tunnel.

CITY PUMPING STATION.—The new city pumping station, at the west end of the tunnel, will be at Eastern Ave. and Lumber St., about 2½ miles above the present station, which will be abandoned. In it will be installed six vertical, triple-expansion, crank-and-fly-wheel pumping engines; three of 25,000,000 and three of 12,000,000 gallons daily capacity. Proposals for these engines are now being invited. The larger engines will deliver direct into the mains of the distribution system, and by a branch main into the present elevated reservoir in Eden Park, which has a capacity of about 100,000,000 gallons. The smaller engines will pump direct into the mains of the high-service system. They will supersede the present system of re-pumping from the Eden Park reservoir to the higher parts of the city.

ENGINEERS.—Mr. Gustave Bouscaren is Chief Engineer to the Board of Water-Works Trustees, and with him are associated Mr. Charles Hermany and Mr. George H. Benzenberg as consulting engineers. All these gentlemen are members of the American Society of Civil Engineers. Mr. J. F. Wilson is Chief Clerk to Mr. Bouscaren. Mr. Alfred Petry, M. Am. Soc. C. E., is Resident Engineer in charge of the tunnel and pump wells, with Mr. John A. Hiller as Assistant Engineer. Mr. Wm. C. Jewett, M. Am. Soc. C. E., is Resident Engineer in charge of the work for the settling and clear-water basins, filter plant, etc., with Mr. Robert J. Devinish and Mr. Andrew P. Birnbaum as Assistant Engineers. Mr Joseph W. Ellms is the chemist and inspector in charge of the laboratory, near the Eden Park reservoir, where special investigations have been made bearing on the use of coagulants in connection with mechanical filtration, and where all cements, oils, paints, etc., delivered by the several contractors are tested and analyzed. To many of these gentlemen we are indebted for information and for courtesies shown during a recent visit to the works.

CONTRACTORS.—The intake pier, river tunnel and pump-well at the eastern, or California, pumping station, were built by F. H. Kirchner & Co., of Cincinnati, and the contract for the land tunnel has been let to the W. J. Gawne Co., of Cleveland, O. The pumping engines at the California pumping station will be built by the Camden Iron Works, Camden, N. J. The grading for the settling basins and filter plant, and the laying of the 60-in. pipe lines are being done by Quigley & Co., of St. Louis, Mo., under a subcontract from August J. Henkel, of Cincinnati. The pipe is furnished by the United States Cast-Iron Pipe & Foundry Co. The railway branch was built by Edward W. White, of Cincinnati; while the steel viaduct carrying this branch over Lick Run was built by the Fort Pitt Bridge Co., of Pittsburg, Pa. The pile and rock revetment for the protection of the Little Miami River bank was built by Thomas Maloney, of Cincinnati. The bridge connecting the intake pier with the Kentucky shore is being built by the Brackett Bridge Co., of Cincinnati.

THE PROPOSED IRISH CHANNEL TUNNEL.

From time to time, projects have been brought forward for the construction of submarine tunnels beneath the sea at depths greater than those at which compressed air can be used. No such tunnel has ever been made, and the only one ever attempted—that under the English Channel—advanced only so far as an experimental heading and not enough to prove the feasibility of the enterprise as an engineering proposition.

Most of the projects of this class have been the work of visionary schemers or promoters and have not received the serious attention of engineers. As we have recently* explained in this journal, the crucial difficulty with any and all such schemes is the danger of encountering large flows of water at a great depth; and while geologists may predict the existence of impermeable strata, their predictions are subject to about as large a measure of uncertainty as the predictions of the Weather Bureau.

One of the narrow seas which it has been several times proposed to cross by a submarine tunnel is that which separates England and Ireland. We have recently learned—we confess with no little surprise—that this project, chimerical though it has seemed to engineers on this side of the water, has secured the approval and backing of a number of well-known engineers in Great Britain. Prominent among them is Mr. James Barton, of Dundalk, a member of the Council of the Institution of Civil Engineers, who will be personally remembered by many of the American engineers who visited England last summer as among the most assiduous in ministering to their pleasure and comfort while they were the guests of the Institution.

We are indebted to Mr. Barton for copies of papers describing the project, for recent information as to its present status and for the plan and profile of the proposed tunnel here reproduced. It will be seen that the total length of the proposed tunnel is about 35 miles, of which some 25 miles are under the sea. The latter part of the works are at a depth of 150 ft. or more below the bottom of the ocean and under water with a depth of 400 to 500 ft. The cost is estimated at £10,000,000 or £12,000,000, including the interest during construction, which it is estimated will require 12 to 14 years.

Besides Mr. Barton's backing, the scheme was examined and approved some years ago by the firm of Hawkshaw & Hayter, of whom the latter will be remembered as a Past President of the Institution of Civil Engineers. It is admitted by the advocates of the scheme that the question whether the traffic which the tunnel would secure would be sufficient to pay interest on its construction is a doubtful one. They are, therefore, asking for government aid for the enterprise, and would very likely have received it ere this except for the extraordinary expenses of the government on account of the South African war, which has made necessary close scrutiny of expenditures at home. Capital, however, has already been enlisted in the enterprise to the extent of a willingness to assume the risks of construction. The Provisional Committee of the Irish Channel Tunnel has offered to construct the tunnel provided the British government will guarantee that upon its successful completion and opening to traffic its revenues shall pay a dividend of 3% on the share capital of £12,000,000. The government would be required to make no payment until the completion of the tunnel, some 12 or 14 years hence, and only then to the extent of making good any deficiency in the net revenues to pay the above-named dividend. Negotiations between the promoters and the government are still in progress and recent information is to the effect that an agreement is anticipated. Among the members of the Irish Channel Tunnel Committee are Mr. Claud J. Hamilton, Chairman of the Great Eastern Ry. Co; Gen. R. H. Sankey, and several well-known members of Parliament.

The route adopted by the Provisional Committee is that selected by Mr. Barton some years ago and approved by Messrs. Hawkshaw & Hayter. As seen by the map, it passes well to the northward of the deep depression in the channel known as Beaufort's Dyke, where the water averages 700 to 900 ft. in depth, and is thus somewhat longer than a direct route would be. On the other hand, the great depth necessary to pass under this deep chasm is avoided.

Our readers will doubtless be curious as we were to learn on what grounds the engineers above named based their conclusion that no difficulty would be found with percolating water in driving the tunnel beneath the sea. We therefore reprint below portions of a paper describing the enterprise which was read by Mr. Barton in 1897 before the Federated Institution of Mining Engineers:

> For the purpose of drainage, it is necessary to have a fall to the shore ends of the tunnels, and this is to be effected by headings which convey the water to the

*Eng. News, Dec. 13, 1900.

sumps at the shore-shafts, where the pumping engines would be placed. The drainage-headings perform an important part in the ventilation alluded to lower down.

The bottom of the Irish channel has been sampled in a rather extensive way by the Hydrographic Department of the Admiralty, and they have found it to be a sediment composed chiefly of ooze, shells, fine mud and sand. The author has devised apparatus by which he hopes to be able to take borings along the line in water of a miximum depth of 500 ft. to ascertain the depth of soft sea-bed to the surface of the solid rock, and to ascertain the nature of the rock, so as to say with confidence what the tunnel will pass through at certain depths.*

GEOLOGY OF THE CHANNEL.—A geological map of the United Kingdom shows the Lower Silurian formation on the surface for a width of some 30 miles, extending in a southwesterly direction from Selkirk and Peebles through Dumfries and Wigton to the shore at the Mull of Galloway; and on the Irish side the same formation is continued across County Down and parts of Louth and Armagh. In Antrim, it is overlaid by the New Red Sandstone, which again is generally covered by Red Marls. These are on the surface north of Belfast Lough; but for the most part of the county of Antrim they are covered on the surface by the tabular formation of trap rock. In Antrim, the Chalk and Greensand in thin beds are also found overlying the Red Marls, being visible on the coast at Whitehead and other places near that place.

The probable lie and extent of the strata under the channel have been laid down by Prof. Hull (lately head of the Geological Survey of Ireland), and he has given his opinion that the data obtained from the strata on each side of the channel are sufficient to enable him to arrive approximately at a fair estimate of the nature of the rocks and the strata to be encountered in making the tunnel. He stated that he was perfectly satisfied that there were no geological difficulties likely to be encountered in the construction of the tunnel which engineering skill would not be able to meet.

The outcrop of the junction between the New Red Sandstone and the Silurian formation would be (Prof. Hull stated), if on land a probable layer more or less pervious to water, but as it had been for ages gradually under the process of sealing by sea-deposit and under great pressure, he did not believe that it would be found a danger, whilst the advantage of tunneling through the marls and sandstone for several miles would largely facilitate and cheapen the tunnel excavation.

The late Mr. W. Topley, of H. M. Geological Survey, London, a well-known geologist, confirmed these views.

Experience of subaqueous tunneling goes to show that the chief dangers of water lie in the approach-tunnels rather than in the portion situated under the bed of the sea or river. In the former case, all crevices remain open, those above the level of low water being channels by which water is carried downwards and thereby kept open, whilst those in the sea-bed during past ages have been gradually sealed up by sea deposits, and that under heavy pressure, which would gradually drive out air and water and tend to calking of all joints. The author's opinion on the subject is strengthened by the fact that in the Mersey and Severn tunnels no leakage occurred under the river beds, and the great spring which was such a difficulty at the Severn tunnel was fresh water, and under the land portion of the tunnel.

The late Sir John Hawkshaw, whose firm were engineers to the Severn tunnel, said: "A tunnel beneath the sea, if only deep enough down, was just as likely to be dry as a tunnel beneath the land."

Sir Douglas Fox, engineer to the Mersey tunnel, said:

When the tunnel was commenced, apprehensions were very general as to the danger of the water coming in through fissures, of which it was surmised the strata cut through would be full. As a fact, only one fissure was encountered, and that was certainly drier than other parts of the work.

Sir Benjamin Baker said on this subject:*

A headway was driven under the Forth a mile, and at Whitehaven ½ mile under water; in both cases, as in that described by Sir Douglas Fox under the Mersey, they found less water under the sea than under the land portion of the work. He thought that might be taken as practically proved to be generally so in rock strata; and the fact had an important bearing upon any future contemplated submarine tunnel, such as a channel tunnel, or a tunnel to Ireland perhaps.

The Red Marl, in the neighborhood of where the tunnel would commence in Ireland, has had shafts sunk in it for salt, which occurs in pockets. The author has been down one of these shafts to a depth of 900 ft. in these marls, and found the bottom absolutely without water, no pump being required except near the top of the shaft for the surface water. This shaft, at its bottom level, would be probably 500 ft. below sea-level. The marls were an easily quarried, solid, slaty rock, the lower strata being hardest.

ESTIMATES.—Estimates at this stage are preliminary, but the experience gained from Alpine and other tunnel borings go a considerable way in enabling those who have carried out large works to form a sound judgment on the data as far as they go, and these estimates help one to form a correct opinion as to the comparative desirability of different routes.

The estimates for the route shown is £8,400,000, but the author and his partners consider that special contingent expenses being probable they should state the cost as between £8,000,000 and £10,000,000.

COMPLETION OF WORK.—In considering the probable time for completing such a tunnel, let us note a few of the long tunnels already made. Probably the longest completed tunnel is that at Schemnitz in Hungary, used as a channel for water from the mines to the Grau Valley—its length is 10¼ miles, its section 10 ft. by 5 ft. 8 ins., and it was commenced in 1796, but not completed until 1878. The first portion for several years was contracted for at £7 per yard, but afterwards it cost much more, and the total cost was about £1,000,000.

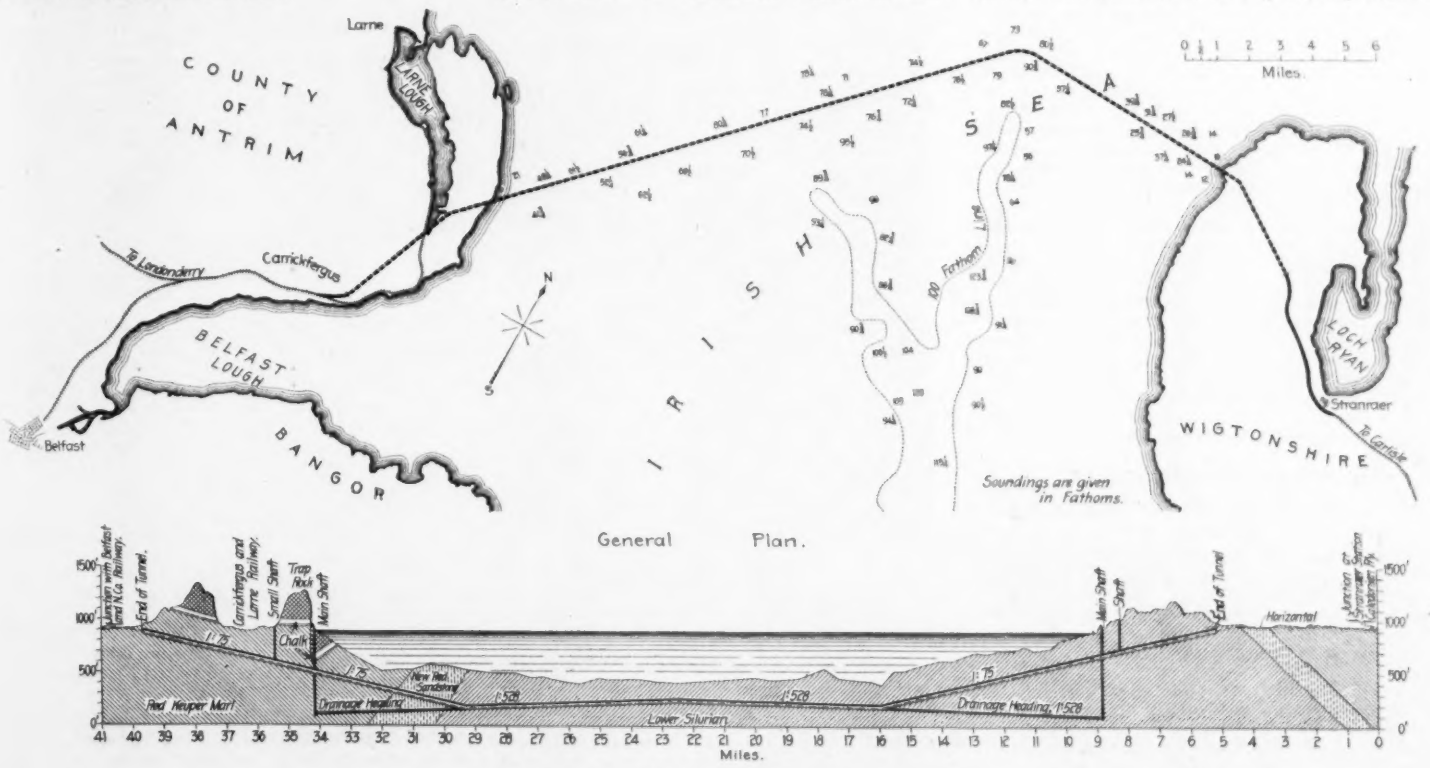
The Mont Cenis, the first Alpine tunnel, is 8 miles long, its progress after compressed-air drills were introduced, was as a maximum 6 yards per day, but averaged only 2½ yards. The cost of that tunnel was £224 per yard. The next was the St. Gothard tunnel, 9¼ miles long, commenced in 1872. Its progress, commencing at 2½ yards per day in 1872, rose to 10 yards per day in 1880, the strata being granite, schist, and gneiss. It was completed in 7½ years, and its cost was £142 per yard, a great decrease from the Mont Cenis cost of £224 per yard. The third was the Arlberg tunnel, commenced in 1880. The length of this tunnel is 6½ miles, the time of completion about 3 years, and the rate of progress, commencing at 7 yards a day, increased to nearly 12 yards, the rock pierced being schist and quartz. This tunnel cost £1,200,000, and its cost per yard is about £107. The Simplon tunnel will be between 12 and 13 miles long, and there again an increase of speed is expected upon those made before it.

The estimates above given for the Irish Channel tunnel include £125 per yard for the tunnel in Silurian rock, and £102 per yard in the marls and sandstones, adding to these prices the cost of pumping and ventilating machinery, and the cost of shafts, etc., and the time would probably be from 10 to 12 years.

VENTILATION.—The question of ventilating such a tunnel, if the trains are worked by ordinary steam-engines, has been practically dealt with in a paper by Mr. Clark Hawkshaw, read before the British Association for the Advancement of Science, in reference to the then proposed tunnel from England to France—the length to be ventilated being nearly the same as in this case. The amount of gases which has to be removed is known from the quantity of coal which would be consumed in the production of the power to work an estimated number of trains per hour; the amount of dilution of those gases to render them innocuous is then ascertained; suitable engines will then discharge by fans, or otherwise, the necessary amount of pure air down the shafts and along the drainage-heading, and then by closed channels under the permanent way and separate from the main tunnel, and discharge the air near the center of the tunnel, from which two air-currents would pass back to the ends. The difficulty of ventilation will, however, be immensely diminished by the use—as the author expects—of electricity as the motive power, which is even now capable of such an application, but which will doubtless be capable of application in better detail a few years hence.

SOUNDINGS.—The next step in the project are accurate soundings at much shorter intervals than those which have been taken, also surveys and levels to obtain absolutely the distances and levels across the channel. Core-borings also are necessary at the sites of the shore-shafts to the full depth, and deep-water borings as already referred to, to ascertain the depth, of soft deposit on the rock under the sea-bed and the nature of that rock.

The next expenditure, in the author's opinion, and that



MAP AND PROFILE OF PROPOSED IRISH CHANNEL TUNNEL.

*Since this paper was read the writer has received a definite proposition for these sea borings in water up to 500 ft. deep, from an experienced firm of borers.

*Trans. Inst. C. E., Vol. LXXXVI., page 91.

of Messrs. Hawkshaw and Hayter, would be to sink the shaft on the Irish side and carry a heading so far as to pass the junction between the New Red Sandstone and the Silurian formations (this would cost £200,000 or £250,000), after which the risks would be minimized and the work would thenceforward be one, the cost and time for execution of which could be closely estimated.

DISCUSSION.

Prof. Edward Hull (late Director of the Geological Survey of Ireland) wrote that Mr. Barton had in his paper so fully expressed his (Prof. Hull's) views on the geology of the proposed tunnel that little remained to be added on this occasion. It was clear that in the absence of detailed submarine experiments, such as the author had suggested, our knowledge of the nature of the submarine rock-bed must be founded upon that of the bordering land-surfaces. Speaking generally, a survey of the coast, both on the Irish and Scottish sides of the North Channel, leads to the conclusion that there are only two sets of formations to deal with, namely, the soft sandstones and marls of the Triassic system on the Antrim side, and the Silurian rocks on the Wigton side. These latter consist of hard green, grey, and purple grits and slates, traversed by dykes of trap. The former would be very easily and cheaply pierced by boring machinery, the latter would offer greater resistance, but not excessive. He thought it probable that the Traissic strata would be found to extend to about 3 miles out to sea from the coast of Island-Magee, and that the Silurian beds would form the remainder of the tunnel. What the nature of the junction of the two formations may be, it is impossible to say at present; it may be a line of fault, or simply an overlap. He fully concurred in the opinion of the author, supported as it was by Messrs. Hawkshaw and Hayter, that one of the preliminary trials should be that of a shaft and a heading driven out from the Antrim coast, in order to pass through the junctions of the two formations and thereby to solve the questions of the nature of the junction, and of the quantity of water likely to be met with at that point.

Mr. T. E. Foster (Newcastle-upon-Tyne) said that it was quite possible that large volumes of water would be found in the New Red Sandstone when driving across the measures, which was rather different from driving along them, as was proposed in the case of the Channel tunnel. The quantity of water would also depend on what might be found at the junction of the New Red Sandstone and Marls and the Silurian rocks, and the shape of the sea-bottom. Until borings were made, it would be premature to give any opinion as to the quantity of water to be met with.

THE D'AURIA AIR COMPRESSOR.*

By Henry G. Morris, M. Am. Inst. Mining Engineers.†

The present paper calls attention to a new form of air-compressor, so extraordinary in character that had I not built several of them and seen them work satisfactorily I would hardly dare to bring it forward as an accomplished mechanical fact: namely, the d'Auria air-compressor, build on the same principle as the d'Auria pumping engine.

This is a non-rotative compressor of the duplex type. So far as steam economy is concerned, it may be said to have less limitations than even a crank and flywheel compressor, for the simple reason that, while in the latter the high degree of steam expansion calls for heavier flywheels, heavier crank shafts, etc., the moving parts in the d'Auria compressor are not in the least affected by the degree of steam expansion, and the machine works as well with a high as with a low expansion.

Since there is no mechanism of levers, etc., employed to equalize the propelling force and the resistance at every point of the stroke (such as is used, for instance, in a Worthington high-duty pumping engine), the question arises, how perfectly smooth action is attained in the d'Auria compressor, starting at the beginning of the stroke with a high initial pressure of steam against no resistance and ending the stroke with a propelling force practically nil and resistance at a maximum.

This result is accomplished by the d'Auria "hydraulic compensator," which is a cylinder fitted with a plunger carried by the same piston-rod which connects the steam and the air piston. The ends of the compensator-cylinder communicate with each other by means of a loop of pipe, turned into the form of a very rigid bed-plate, which adds to the strength of the machine and preserves under all conditions the alinement of the piston-rod. This cylinder and pipe are filled with water or any other liquid; and, as there is no loss of liquid beyond that which may leak through the stuffing boxes, they are easily kept full from any source of water supply, through a small pipe and two check valves.

When the compressor is in action the liquid column contained in the compensator pipe is affected reciprocally, to and fro, by the plunger, and acts in exactly the same manner as a balance-wheel in a watch, taking up the excess of energy in the first half and giving it back, with an exceedingly small loss due to friction, in the second half of the stroke.

The action of this compensator is so perfect that the machine is never bolted down to the floor on which it stands, and, under such conditions, can be run at a high rate of speed without vibrations. I have seen an 8 × 9 × 8-in. compressor of this type work suspended in the air from chains, and also run while on rollers, and another of the same size making 340 strokes per minute without being bolted to the floor—and under these conditions I was able to balance upon it a five-cent piece on edge.

These compressors have no dead centers. The cycle of their action being limited to the period of one stroke, they are able to start and stop instantly; and if fitted with a sensitive pressure regulator they will stop completely on a small variation of air pressure, and will start promptly when that pressure falls slightly below the normal.

It may be asked, what would be the effect of a sudden release of load on the compressor, such as might happen by the breaking of the air pipe? This contingency is met in the d'Auria compressor, as in the d'Auria pumping engine, by a simple and effective device. The exhaust steam in the steam cylinder is cut off by the piston itself about 1.5 ins. from the cylinder head; and from this point on a considerable amount of steam cushioning is done in the cylinder, stopping the piston, under ordinary conditions, at about ⅜-in. from the cylinder head. Of course, this ⅜-in. clearance is filled up with steam at boiler pressure, which, while it does no harm, does a considerable amount of good by keeping the piston and cylinder head hot when steam is admitted. On the other hand, the compensator plunger has a number of slots, which, in case the stroke becomes longer than normal (that is, if the clearance becomes less than ⅜-in.), overrun the bearing of the plunger and open a by-pass for the column of water which is pushing the plunger forward. Thus the pressure on both sides is equalized, and the pistons are prevented from striking the cylinder head. Of course, this device comes into play only when the load is suddenly released. Under ordinary conditions—that is, with ⅜-in. of clearance in the steam cylinder— the by-pass in the compensator will not open.

In larger sizes the d'Auria compressors are made compound, both in air and steam, and fitted with the most approved steam and air valves to insure economy of steam. A d'Auria compressor of 3,000 cu. ft. capacity per minute, compound in steam and air, with inter-cooler all complete, weighs about 46,000 lbs., occupies a floor space of 25 × 8 ft., requires no other foundation than a floor to support its weight, and does not need even to be bolted to the floor. A compressor of the crank and flywheel type, capable of doing equally sufficient work, and of the same capacity, would occupy a floor space of about 56 × 18 ft. and its flywheel alone would weigh 45,000 lbs., the total weight of the machine being probably about 170,000 lbs.

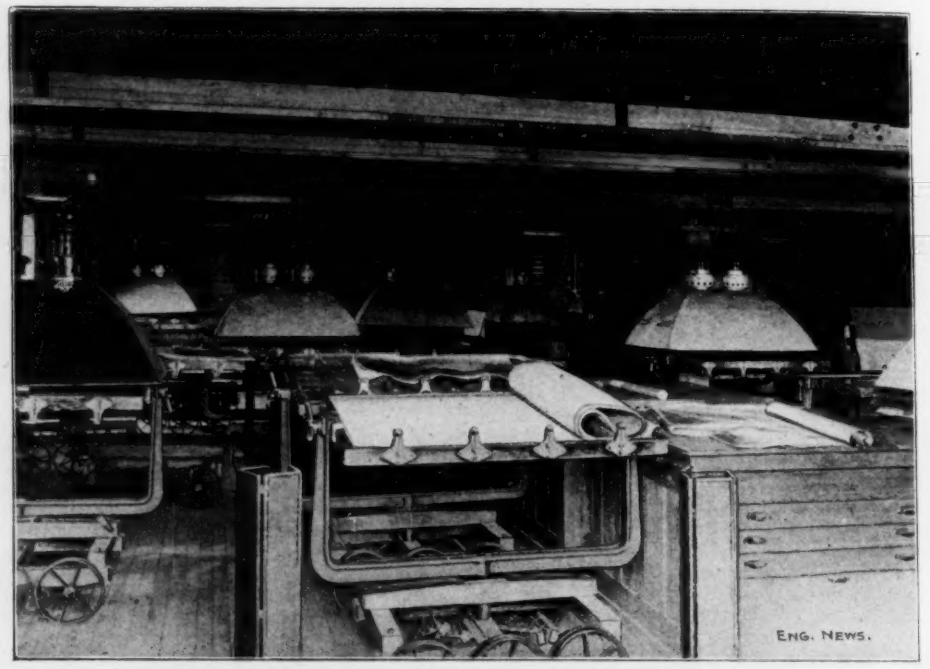
Where space is a consideration, the new type offers considerable advantages, occupying only one-fifth as much area as the former type. In weight, it is as one to four, involving much saving in the cost of foundations, which is an important item. Moreover, it can be moved from place to place without any trouble, being, in the full sense of the word, a portable machine. No matter what its speed it will always start and stop promptly by opening or throttling the steam, without any dead center.

*From a paper read at the Richmond meeting of the American Institute of Mining Engineers. The D'Auria pumping engine, designed on a similar principle, was described in Engineering News of Aug. 26, 1897.

†Engineer and Machinist, 408 Philadelphia Bourse, Philadelphia.

BLUE-PRINTING BY THE ELECTRIC LIGHT.

We illustrate herewith a device which in some form or other will undoubtedly come into very extended use in shops where it is necessary to prepare many blue-prints. When sunlight is depended upon entirely for making prints there are many days, and even whole weeks, when no printing can be done, and this is a very serious matter if the drawings are urgently needed in the shop or the place of installation of machinery. In order to insure the continuous production of prints in all kinds of weather and at all times of the year the General Electric Co., of Schenectady, N. Y., have made use of the enclosed arc lamp



BLUE-PRINT ROOM ARRANGED FOR PRINTING BY ARC LIGHT.
Equipment Manufactured by the General Electric Co., Schenectady, N. Y.

which they have provided with suitable reflectors, frames and other attachments for convenience in making blue-prints, as seen in the illustration.

Of course, the chief advantage of the electric blue printing process is that it enables a factory to turn out blue prints at night, or during days when blue printing by sunlight would be extremely slow, if not entirely impracticable. While it requires about three times as long to make a print by the electric arc light as by bright sunlight, the more convenient arrangement of lamps and frames enables many more frames to be handled than when using sunlight. In the latter case the frames must be made ready in a room not too brightly illuminated and then wheeled out into the bright sunlight. In electric printing the frames may remain perfectly stationary and the lamps can be moved back and forth on overhead beams.

The lamps are of the standard five-ampere type manufactured by the General Electric Co. They burn in multiple on 110 direct current circuits with 80 volts at the arc. Equally good results may be obtained with the 7½ ampere alternating current lamp or with the 220 volt power circuit lamp.

The lamps are furnished with light opal enclosing globes and are mounted in pairs on a small carriage, which may be run back and forth on a beam attached to the ceiling. Over the lamps a sheet iron hood with a white interior is arranged to reflect practically all of the light downward, illuminating the area beneath it with a brilliant and uniform light.

The General Electric Co. is also working on an equipment for printing from ordinary glass negatives by electric light, which when perfected should be of great value to photographers.

6,000-HP. WESTINGHOUSE ENGINES FOR THE NEW YORK GAS AND ELECTRIC LIGHT, HEAT & POWER COMPANY.

New York city will shortly have four great electric power generating stations, each of them exceeding in its capacity any electric power station in any other city in the world. Two of these power stations are now completed and in operation, furnishing current respectively to the electric railway lines of the Metropolitan Traction Co. and the Third Avenue R. R. Co. The other two, now under construction, are to furnish current respectively to the Manhattan Elevated Railway lines and to the electric lighting and power destribution system of the Edison Electric Illuminating Co. of New York.

In each of these stations the engines and generators are of phenomenal size. We illustrate in the accompanying cut one of the 6,000-HP. engines and generators for the New York Gas and Electric Light, Heat & Power Co. The following description of the engine has been furnished to us by the Westinghouse Co., which is building eight of these engines to be placed in the new station:

The engine is the familiar inverted cross compound type. The base consists of three rectangular pieces, weighing in the aggregate 100 tons. Upon this base are set three housings, with circular flange tops. Each housing, consisting of two parts which bolt together, is very stiffly ribbed. Bolted on the housings are the crosshead guide frames, and each guide frame is surmounted by its cylinder. There is one high-pressure and two low-pressure cylinders, the high-pressure cylinder being in the middle.

The high-pressure cylinder is 43¼ ins. in diameter and the two low-pressure cylinders each 75½ ins. in diameter. The stroke is 60 ins. and the speed 75 revolutions per minute. The high-pressure cylinder is not jacketed, but is designed to use superheated steam. From this cylinder the steam passes into a reheating receiver 4 ft. 6 ins. in diameter and 23 ft. in length over all, with a volume of 219 cu. ft., and containing 110 tubes, giving about 1,200 sq. ft. of heating surface. This heater is placed horizontally across the rear of the guide frame portion. The low-pressure cylinders are steam jacketed.

The valves are all double-ported and as close together as will allow of proper valve-gear construction. The high-pressure cylinder has balanced poppet valves, actuated by a releasing gear, and the low-pressure cylinders Corliss valves, operated by the usual wrist plate and tie rods. This unusual combination of valves was substituted for all-Corliss valves because of the high temperature at which steam enters the high-pressure cylinder. This steam, which is under a pressure of 175 lbs., is superheated 200°, making its total temperature 577°. At this temperature it is practically impossible to provide the efficient lubrication necessary to the proper working of Corliss valves.

Each connecting rod is a steel forging and is 13 ft. 9 ins. long between centers. The top end of each connecting rod is of the ordinary solid type, with wedge adjustment, and the bottom end is of the so-called marine type. The crosshead pins are 14 x 14 ins., and the crank pins, 14 ins. in length, are 22 ins. in diameter. The cranks are of cast steel and are of the usual type. They are set at unequal angles apart, approximately 120°, selected to give the most nearly uniform turning movement.

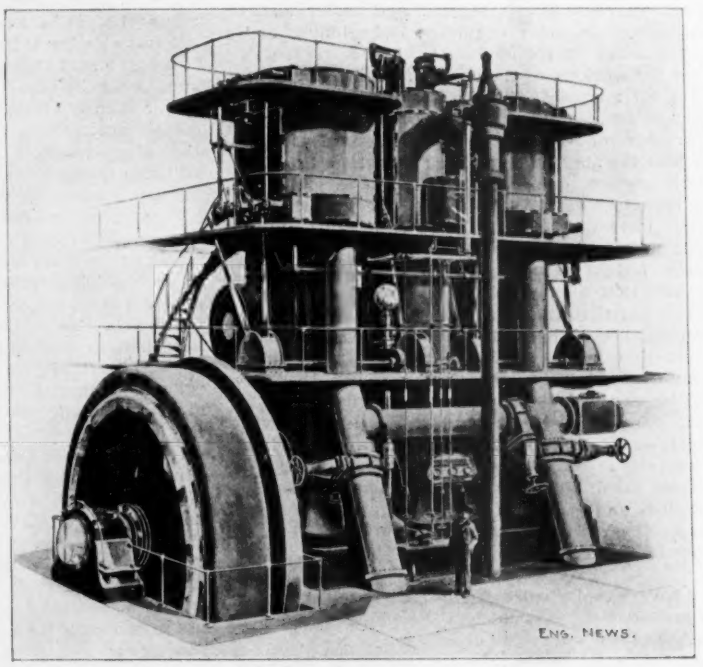
The main shaft is of open hearth, fluid compressed, hydraulically forged steel, as are the connecting rods, and both were supplied by the Bethlehem Steel Co. The shaft is 29½ ins. at the bearings, which are 26 x 60 ins. The shaft is hollow, of 10 ins. internal diameter at the wheel fit and 9 ins. at the bearings. Its total weight is 136,000 lbs.

An interesting departure from ordinary engineering practice is to be found in the way motion is given to the eccentrics that operate the valves. Usually the eccentrics are mounted directly on the main shaft; but in this engine the eccentrics are mounted on a lay shaft located at the level of the first platform. This auxiliary shaft is driven by a spiral gear. The advantages to be derived from moving the eccentrics in this way are manifold. The chief one is, however, the reduction in the size of the eccentric straps. The diameter of the main shaft is 29½ ins., while the diameter of the lay shaft is only 6 ins.; the size of the eccentric straps and the friction of their rubbing surfaces are reduced accordingly.

The flywheel is of novel design and comparatively small, because a more uniform turning moment is given by the three unequally spaced cranks than is possible with two cranks. The center is of air furnace iron, and the arms and rim of cast steel, made in five sections, each comprising 72° of rim and two of the ten radial arms. These five sections are joined together by I-links shrunk into pockets, and are bolted into the hub, forming a wheel 23 ft. in diameter and of 9 ins. face, having a radial depth of 30 ins.

Upon either side of this wheel are riveted upon its rim and flush with its face five circular pieces of 72° angular length each. These pieces are of 3¾-in. face and 27½-in. depth, making a total face width of 16½ ins. These side segments are also fastened together by I-links, but the joints are broken with those of the central wheel rim. The peripheral speed of the wheel is 5,416 ft. per minute.

An automatic stop-valve is provided, which shuts off the steam supply in case the speed exceeds any fixed limit. In outline it may be described as a valve which is closed by steam admitted through a three-way cock. In a pocket in the face of one of the high-pressure crank cheeks is pivoted a short weighted lever, balanced against centrifugal force at normal speed by a helical spring. Should normal speed be exceeded, the weighted lever flies out and engages with a spring lever pivoted on the engine base. This action turns the three-way cock above mentioned, admitting steam to a chamber of the angle stop valve on the steam supply main, and promptly closing it. There is also provision at a number of points about the engine for hand control of this same stop valve.



6,000-HP. ENGINE FOR SUPERHEATED STEAM.
Built by the Westinghouse Machine Co., Pittsburg, Pa., for the New York Gas & Electric Light, Heat & Power Co.

The engine is 37¼ ft. from the floor line to the top of the cylinders, 41 ft. across the front and 23 ft. from front to rear. Its entire weight is more than 1,500,000 lbs., and above 15,000 separate pieces are required in its construction. So strongly built is it that it can deliver in an emergency 10,000 HP., which is almost double its rating at most economical load. Each engine is to be coupled direct to a 5,000-K-W. generator of the revolving field type. The armature of this generator is to be pressed on the shaft alongside the flywheel, and in addition to being securely keyed to the shaft it is to be rigidly attached to the flywheel hub by means of direct bolting. The outer end of the generator shaft is to be supported by a heavy pedestal carried on an iron sub-base.

A METHOD OF WELDING COPPER is described by Prof. J. R. McColl in the University of Tennessee "Record" for April. The copper is treated with potassium nitrate and a cyanide, after which it is welded to itself, or to iron or steel, in the same way that iron is welded in the ordinary forge shop. A clean fire of coke or charcoal and a temperature of the copper considerably below a white heat insured the best results. A temperature above this made the metal brittle in working, while one much below would not give sufficient fluidity to the flux. In tension tests the welded joints developed practically the whole strength of the copper.

AMERICAN LOCOMOTIVES AND CARS IN EGYPT.

The following extracts from reports of officials in charge of the Egyptian State Railways relating to their experience with American rolling stocks, are given in the New York "Journal of Commerce." The part first quoted is from the report of Mr. F. H. Trevithick, of Cairo, Superintendent of Rolling Stock. The second is from a report by Major Johnstone, President of the Egyptian Railway Board:

REPORT OF THE SUPERINTENDENT OF ROLLING STOCK.—The equipment of American make now in use is 20 locomotives, 300 wagons, and 9 machine tools; besides these there are 22 locomotives which have not as yet been put into traffic. The 20 locomotives in use are of the freight type, and of similar weight and power to the engine we are in the habit of using on these railways; they have been manned by drivers and firemen of Egyptian nationality only, and, inasmuch as they have already run an average of nearly 70,000 miles without having entered the workshops for general repairs, they have earned for themselves a satisfactory reputation as regards design and quality of material.

The workmanship of these locomotives, with the exception of the working parts, is rough, and far short of the finish that is considered desirable by European engineers, and it would be a satisfaction if a mutual standard of finish could be fixed, in order that firms might compete on the same basis. The expense incurred in neatly finishing portions, other than working portions, is very considerable and goes far to account for the difference of cost between the American and English make of locomotive, while it is difficult to gage to what extent a high standard of finish is fruitful of good through the greater interest and care the working staff is likely to take in attending to a well-appointed machine.

The make of American and English locomotives differs so widely that it does not follow that two engines, one American and one English, of similar weight and power, and equally good in design and quality of material, should give the same good result in a strange land, where for many years the working staff has been accustomed to the use of the latter type.

In introducing a new type, intricate details have to be simplified to suit the capacity of the mechanic, and the latter trained to the new conditions; moreover, the American engines appear to consume more coal. These two conditions in a country where the mechanic adapts himself slowly and unwillingly to changes, and where coal is expensive ($6 a ton), must ever be important factors when comparing the utility of the English and American locomotive for use in Egypt.

The 300 wagons are of 30 tons carrying capacity; the workmanship is rough to an extent affecting their satisfactory working, but it is an example of what can be accomplished by labor-saving appliances; with further experience and attention, wagons so constructed will doubtless give every satisfaction.

REPORT OF THE PRESIDENT.—Turning to the improvements effected during the year, that which has had the greatest effect is the putting into service of 200 30-ton American wagons, ordered by my predecessor. The result has exceeded my anticipations; the complaint of want of wagons has almost ceased to exist, partly no doubt because the demand is not at present so great as it has sometimes been at this season, and partly from improvements in other branches of the service, but mainly owing to the great addition to our carrying power, which is represented not only by the capacity of the wagons, but by the fact that, owing to their extreme lightness, our goods engines can draw 20% more net load in these than in our ordinary stock. These wagons have been much criticised, and I am bound to say that they possess many minor defects, but there is a conclusive answer to all these criticisms. These very light wagons are produced by a special process, for which only two firms, one in England and one in the United States, possess the necessary appliances. The English firm lays itself out for a heavier class of work, which finds favor with English engineers; its prices are high, and, as it is extremely full of work, it is not in a position to give very quick delivery. The American firm lays itself out for a very light and cheap, while fairly serviceable class of work, which finds favor in that country and is very rapidly produced.

Thirty locomotives have been ordered during the year. It will probably be necessary to order about this number annually for some years to replace worn-out engines and meet the ordinary expansion of traffic. The American offers were in every case the most favorable, but as American firms do not make engines to our standard designs, our order for ten was given to Glasgow on a tender lower than that of any European firm, for a design prepared by our locomotive engineer, which seems likely to prove very suitable for heavy passenger, and perhaps also for light, fast goods trains. It is very similar to a type introduced on the Great Western Railway some 15 years ago, which was found unsuitable for fast express work, but is used, I am told for express goods trains. The time of delivery is, however, so long that it is a question whether we shall not have to give another order to America before they arrive; but I understand that the firm are making special efforts to anticipate their contract date.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

Railway companies who wish to buy locomotives will in the future find only two important concerns to bid upon their specifications, viz.: the Baldwin Locomotive Works and the American Locomotive Co. The latter concern, the organization of which is just announced, is to own the Brooks, Schenectady, Pittsburg, Richmond, Cooke, Rhode Island and Manchester works. Mr. S. R. Callaway has resigned his position as President of the New York Central & Hudson River R. R. Co. to take charge of the new company. The only other works building standard locomotives not included in the consolidation are the old Rogers works, at Paterson, and the Dickson works, at Scranton. The Rogers works was closed some months ago, and has recently been sold. The Dickson plant, at Scranton, is not included in the recent sale of the remainder of the Dickson works to the Allis-Chalmers consolidation. Whether either the Rogers or the Dickson works will furnish any effectual competition to the two big concerns remains for the future to determine. It may be noted, however, that the combined capacity of both these works is only some 400 locomotives per annum, while the Baldwin and American concerns will be able to turn out a total of considerably over 3,000. If competition develops in the locomotive business, it is more likely to come from some of the several enterprising builders who have in the past confined themselves chiefly to special classes of locomotives for mining, logging, or contractors' work, or for narrow-gage roads.

The official reports of the President and the Chief Mechanical Engineer of the Egyptian Railway Board, in regard to the performance of American locomotives and cars on the government railways of Egypt, are distinctly favorable. These reports, an abstract of which is given in another column, are gratifying to American builders, but must be somewhat unpleasant reading for English builders and a part of the English technical press. The reports are so definite that they effectually refute the ideas of certain foreign critics to the effect that American engines (and other products) may be cheap, but are ill made and inefficient. Three particular points are mentioned concerning the locomotives: First, an apparent greater coal consumption; this, however, is evidently not fully determined, as it is merely mentioned, no figures being given, and the statement being simply that the engines "appear" to consume more coal than English engines. Second, good design and construction, as shown by the fact that at the time of the report the engines had averaged 70,000 miles without requiring to be sent to the shops for general repairs. Third, the comparatively rough finish of parts which are not working parts. This is an objection frequently urged against American engines, but the report distinctly states that it does not apply to the working parts, and that the expense of a general high finish goes far to account for the higher cost of English engines. That the workmanship of the working parts is good is shown by the wording of the report and by the good performance of the engines. That a general high finish is not only costly but out of place on engines for the more or less rough service and the handling incident to railway operation in Egypt, and under similar conditions in other countries, is beginning to be understood by the engineers who are responsible for the working of the engines, but it is evidently not yet recognized by the English builders. The report further shows that in considering the performance of American engines introduced on lines where the staff has long been accustomed to English engines, due account must be taken of the predjudices of the staff and of the fact that the men have to learn how to operate and maintain the new engines to advantage. In regard to the steel freight cars imported from America, it is stated that too much has been sacrificed to lightness, but that this sacrifice was well worth making in view of the great gain in carrying capacity, at a time when this was a matter of the utmost importance. This one defect is shown therefore to be outweighed by the practical advantages of the cars in operation, and the experience with these cars will enable improvements to be made in others that may be ordered in the future. The report taken as a whole shows that the American engines and cars are of low cost, are built quickly and delivered promptly, and are giving good service.

"May Revolutionize Applied Electricity" is the startling headline which a Pacific Coast newspaper places above the description of a new storage battery. We quote the following extracts from the description:

> George T. Eyanson, of Philadelphia, is the inventor of a new electric battery that promises to revolutionize the application of electricity to commercial purposes. The electric energy in the Eyanson battery is generated by a fluid of a light red color. The battery itself is primary in some of its essentials and secondary in others.
>
> The Drexels, John Jacob Astor, John Lowber Welsh and other capitalists of Philadelphia, representing an aggregate wealth of $444,000,000, are backing Mr. Eyanson.

We have ourselves seen an astonishing amount of energy generated by "fluid of a light red color," and 444 is well known to be a combination of magic potency; but it is to be regretted that the reporter fails to state just which "essentials" of this remarkable battery are "primary" and which are "secondary."

Elsewhere in this issue we print an account of the proposed Irish Channel tunnel, with an authoritative statement by its principal promoter concerning the engineering features of the enterprise. We are credibly informed, as more fully stated elsewhere, that English capitalists stand ready to undertake this work, and guarantee its successful completion provided a government guarantee of profit is given. After carefully considering the arguments advanced, however, we are unable to look hopefully upon the enterprise from either an engineering or a financial standpoint. It is assumed by the promoters of the tunnel that the mud which covers the ocean bottom forms a water-tight seal and prevents the sea water from percolating into the underlying rock. It is true that some short submarine tunnels have been driven in dry rock; but on the other hand other tunnels in a similar situation have encountered strong flows of water, so that work has only been possible by the aid of compressed air. As for the theory that a mud bottom acts as a seal to shut off water from the rock strata beneath, experience in soft ground submarine tunnels would tend to entirely contradict this idea. Of course, no man can say it is an impossibility that a tunnel may be driven for 35 miles beneath the ocean bottom without encountering more water than pumping machinery could handle; but to induce capital to take such risk, the burden of proof is on the promoter, to show that absence of water-bearing seams in the rock can be counted on, not as a possibility or even a probability, but as a certainty. It will be evident that even a small opening discharging water under the enormous head of over 600 ft., would be a most difficult thing to handle. It seems strange, indeed, if capital can be induced to take so great a risk, merely on the strength of geologists' conjectures.

There are other engineering questions in connection with the enterprise, also, that seem to need more positive solution before the proposition should be considered in any sense a safe and certain one. For example, no one has ever ventilated a tunnel 35 miles long. The longest railway tunnel now existing is barely a quarter of this length. It may be said that it will be no more difficult to ventilate a 35-mile tunnel with electric motive power than the 9-mile St. Gothard, operated with steam locomotives; but it must be remembered that the ventilation must be such that travelers will ride through the tunnel in preference to taking the journey by water.

Turning to the financial aspect of the enterprise, the promoters admit that it can hardly hope for traffic at the start sufficient to pay the interest on its cost, which is estimated at $60,000,000, and they are, therefore, asking the Government to make up the deficit. To us, however, it is far from clear how the tunnel could compete at all with the present water transit, for either passengers or freight. Tunnel riding is always disagreeable, and there are few passengers who would not prefer a sea trip of 20 miles or so to riding for 35 miles through a tunnel. As for freight traffic, it must be borne in mind that the English and Irish railways are of different gage, so that transshipment would be necessary in any event. It is well known that English rates for sea carriage are very low, while the rail rates are very high. Since the freight must be transferred in any event, it is far from clear how the railways could haul trains through the tunnel with the added expense of electric motive power, for materially less than the goods could be carried across by water. In this connection the English engineers might study with profit, perhaps, the American system of car transfer ferries. If the English and Irish railways are willing to offer an annual sum equal to the interest on the cost of the proposed tunnel, and a fair allowance for its maintenance and operation, for transferring their trains across the Irish Channel, we believe they could find plenty of Americans ready to undertake the contract.

The possible dangers from surface water supplies, even when drawn from sparsely settled drainage areas, has been illustrated anew at New Haven, Conn., during the past few weeks. As shown in more detail in an official report published elsewhere in this issue, 455 cases of typhoid fever and 54 deaths were reported in a few weeks, nearly all from a section of the city supplied from one water-works reservoir. The efficient work which competent boards of health can do is shown by the fact that in this case, immediately upon the reporting of six cases of typhoid in a single day, an investigation was started which resulted in the location of the origin of the epidemic and the shutting off of the water from the reservoir during the following day. Of course, each city should strive to so guard its water supply that such an epidemic could not occur. Of the various ways to attain this end the following may be named: (1) Purification of the

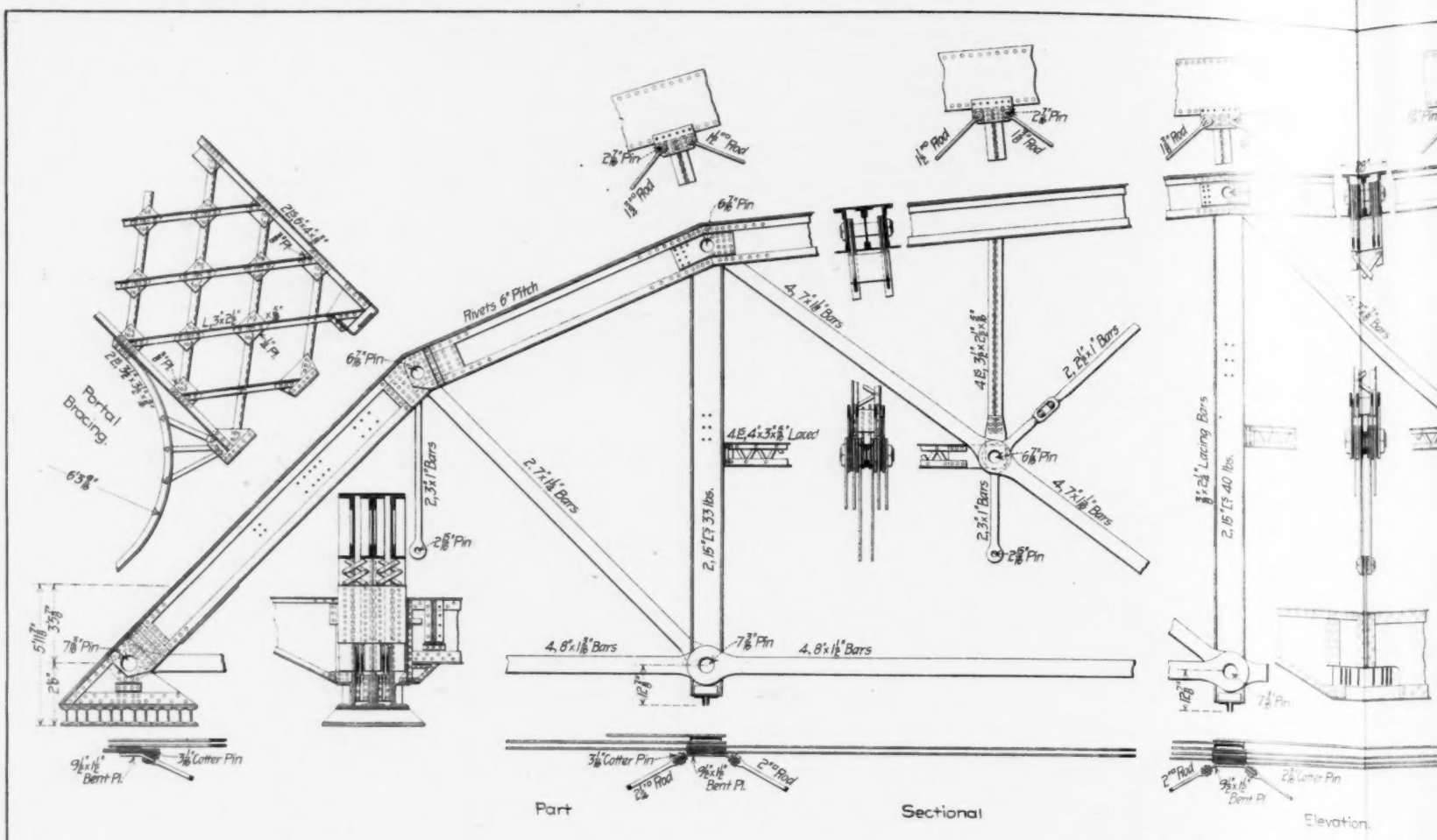


FIG. 4. DETAILS OF TRUSS.

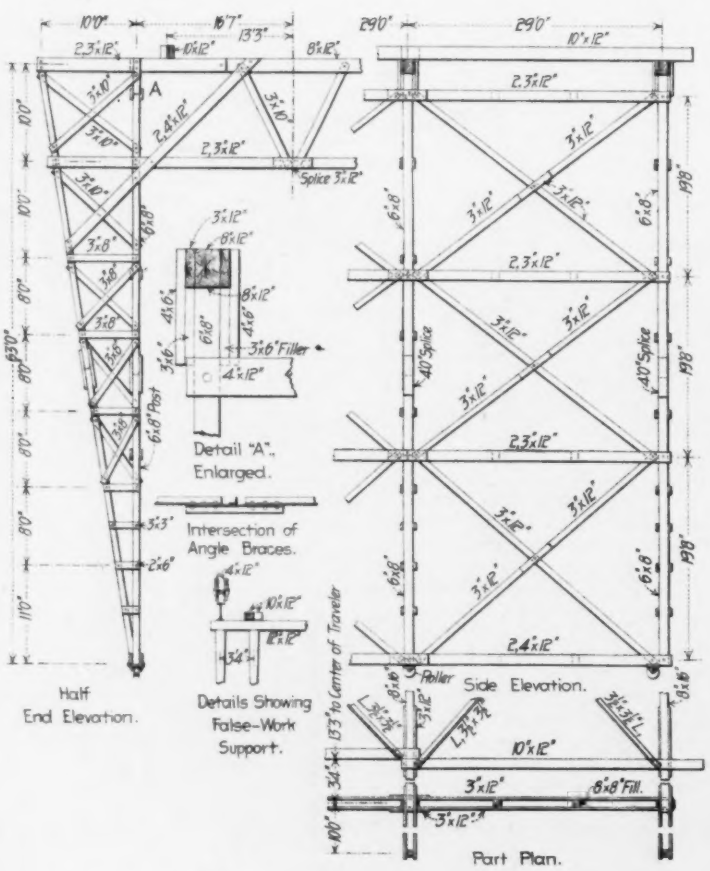


FIG. 11. DETAILS OF TRAVELER.

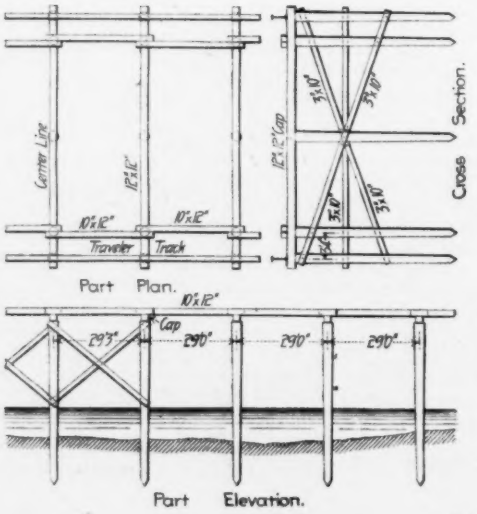


FIG. 10. FALSEWORKS.

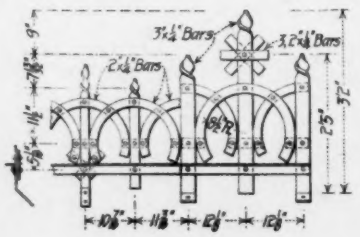


FIG. 9. PORTAL CRESTING.

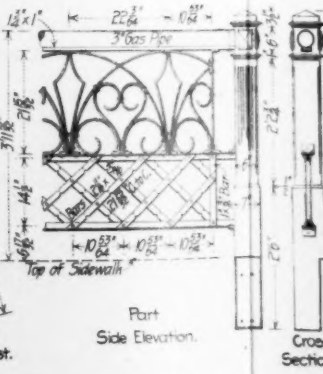
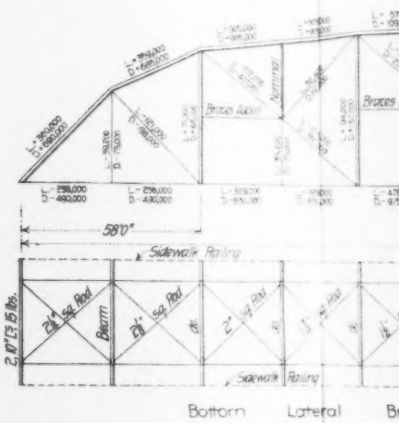
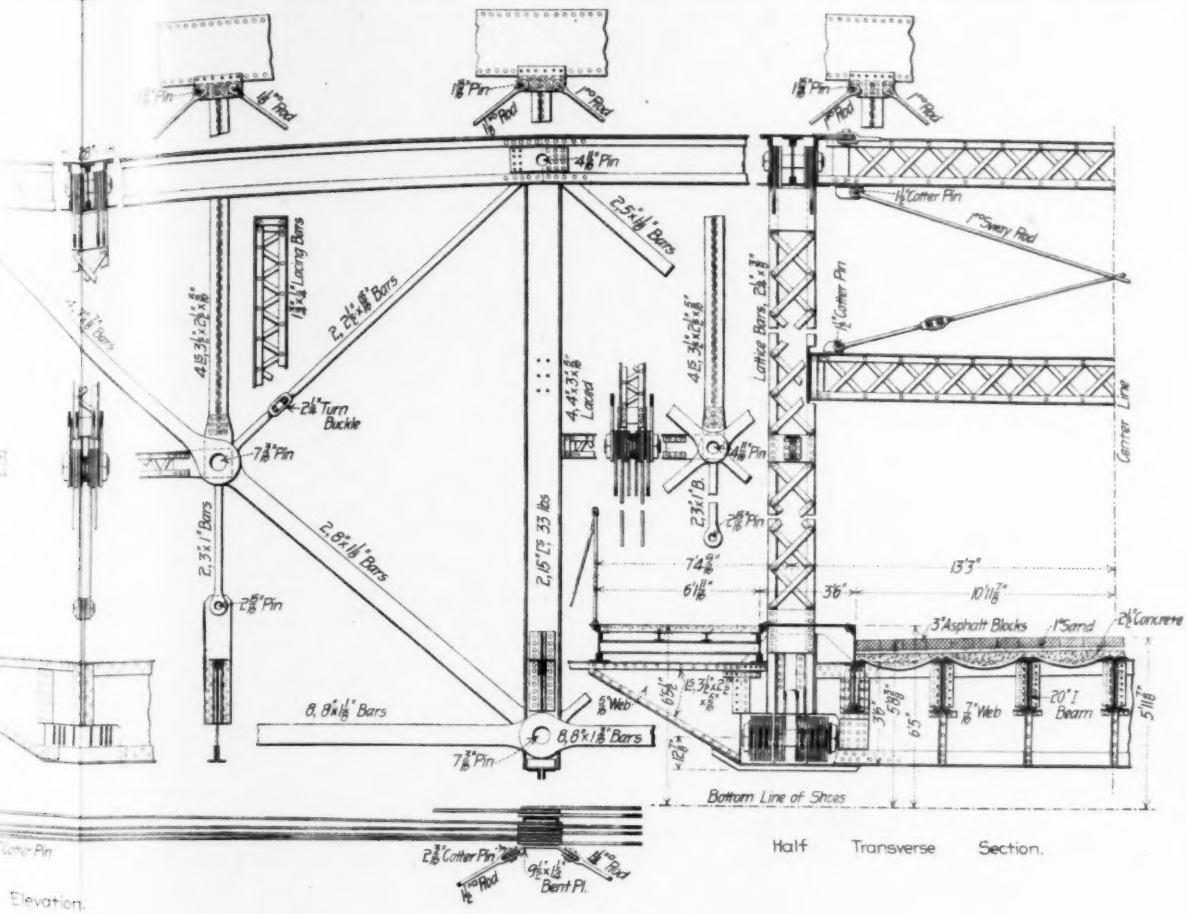


FIG. 8. HAND RAILING.





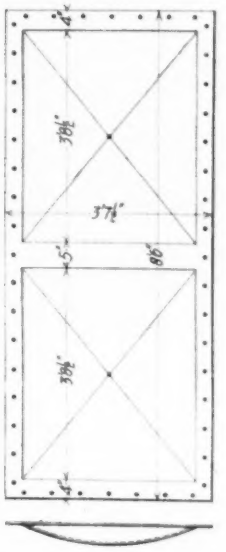


FIG. 5. BUCKLE PLATES FOR FLOOR.

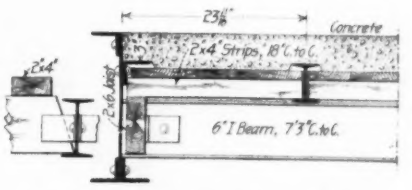
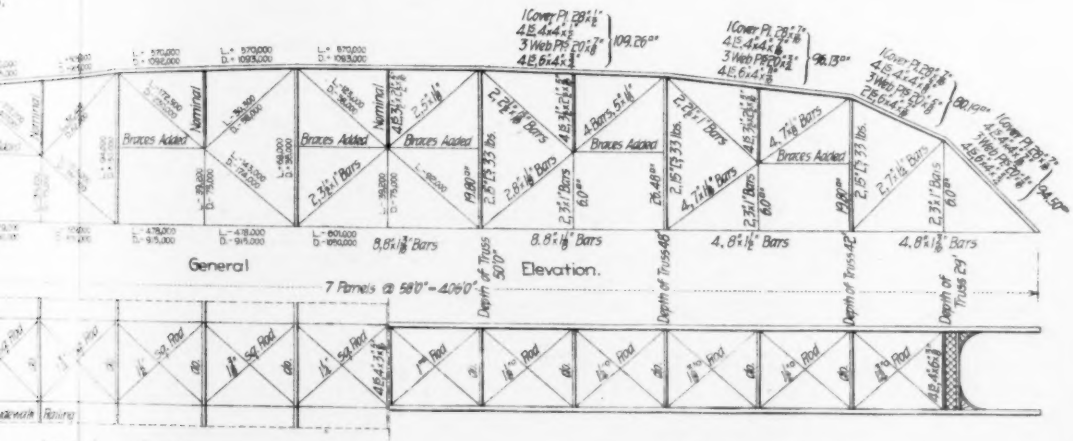


FIG. 6. METHOD OF CONSTRUCTING CONCRETE SIDEWALK.



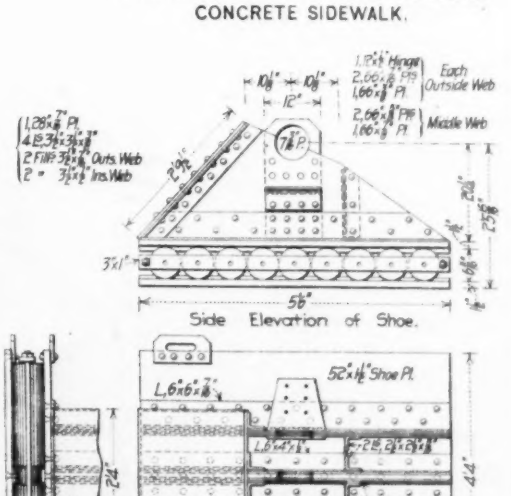
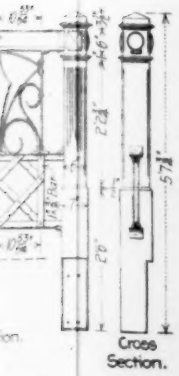


FIG. 3. STRAIN SHEET.



COLUMBIA HIGHWAY BRIDGE,
406 FT. SPAN, OVER THE MIAMI RIVER
AT HAMILTON, O.

Wabash Bridge & Iron Works, Builders. C. E. Howe, Chief Engineer.

L. A. Dillon, County Engineer and City Civil Engineer.

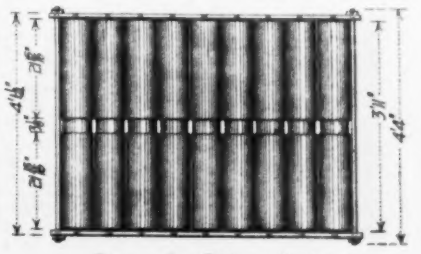


FIG. 7. EXPANSION BEARING.

CHAS. HART, LITH., 88 VESEY ST., N. Y.

whole supply; (2) acquisition and depopulation of the drainage area; (3) the pail system for the removal of all excreta from habitations in the drainage area; (4) sanitary patrols to guard against all forms of pollution; (5) arrangements with local health officers and attending physicians in the drainage area for reporting all cases of typhoid fever to the authorities of the city whose water supply is involved. The last three measures are applicable where the whole drainage area is not depopulated, as is rarely the case, and may be advisable, at least in part, even when the water is purified. Sanitary patrol and local reports of typhoid cases, particularly the latter, may prove to be broken reeds if too much reliance is placed upon them. Great good may be done by acquiring and depopulating portions, sometimes even small portions, of a drainage area. The time will come when both this and purification will be applied to nearly all surface water supplies. Meanwhile, frequent and preferably constant sanitary inspection of drainage areas and systematic analyses of samples of water collected therein should be insisted upon. These precautions, combined with prompt and thorough returns of all cases of typhoid fever occurring within the city will do much towards preventing the rise and checking the spread of water-borne diseases.

CONCENTRATION IN THE STEEL INDUSTRY.

The announcement that the United States Steel Corporation will concentrate its manufacturing plants and abandon many of the outlying and smaller works which were absorbed in effecting the consolidation, is perhaps the most important development of the company's policy which has thus far appeared. According to this announcement, the American Bridge Co. is to build a great structural works in the vicinity of Pittsburg to employ nearly 5,000 men, and will remove to it the machinery from a number of the smaller bridge shops in the East and South. The American Sheet Steel Co. is to concentrate its productive capacity at the New Kensington and Vandegrift works, abandoning a number of mills in Ohio and West Virginia. The American Steel & Wire Co. expects to concentrate a large proportion of its business at Neville Island, near Pittsburg, where works estimated to cost $10,000,000 are now being built. The plants to be abandoned are said to include those at Worcester, Mass., Newburg, N. Y., Cincinnati, O., and Everett, Wash.

It may be said, very likely, that it is nobody's business what the United States Steel Corporation does with its own property; but we do not think the public generally takes just this view of the matter. Changes like these are a most serious matter to the cities and towns and States in which are located these factories marked for abandonment. The thousands of employees, who find their means of livelihood gone unless they will remove with their families to some distant city, are not likely to look with any more favor on the billion dollar combination for this latest evidence of its much-heralded beneficence.

We may contrast with this new policy of the Steel Corporation the course taken by Hon. Abram S. Hewitt in refusing to allow his works at Trenton to enter the consolidation. He has publicly stated that he rejected an advantageous offer for these works, foreseeing that they would be abandoned and that employees who had been with the company for a generation and who had built their homes there would be thrown out of work and forced to sacrifice their savings of years in order to remove where employment could be obtained.

Of course it is urged that the works which are to be abandoned are located where they cannot carry on production most economically; and it will be said that if they had been left in operation as independent concerns they would have been eventually driven from the market by their better located competitors. Perhaps this is true in some cases, but where it is true, what shall we say of the trust organizers who bought such obsolete and out-of-date establishments at an exorbitant price? How much better for the stockholders of the trust it would have been to leave them outside and let them meet a natural death.

The real facts of the case are that the trust was not at all anxious to face the competition of some of these "badly located and uneconomical concerns" which it now proposes to dismantle. Location is only one factor in the success of a manufacturing enterprise. Often it may be a very small factor. Anyone familiar with the bridge industry, for example, can call to mind instances where business ability and enterprise built up a great and prosperous industry in locations where natural advantages were lacking.

We pointed out in this journal some years ago that a centrifugal tendency has developed in manufacturing industries. The West and South are not content to depend on the East for manufactured goods. New England and New York are not satisfied to import all their iron and steel manufactures from Pennsylvania and Ohio. Further, while the policy of concentration may show an apparent profit, it is very doubtful whether this is not in the end more than offset by expenses which the books do not show. A local concern has often a hold upon local trade that a concern a thousand miles away cannot secure. You may manufacture a bridge more cheaply in Pittsburg; but a rival which is within a hundred miles of the place of erection may spend less money by the time the structure is in place. A new factor, however, has entered into the calculation. Since the interests in control of the Steel Corporation and those which control the great railway systems are so nearly identical, it may prove the policy of the Steel Corporation to so conduct its operations as to furnish the largest railway traffic. The local consumer may have to pay more than when he supplied his needs at the local mill, now dismantled, but the benefit will accrue to the railways. If considerations like these dictate the concentration policy which the Steel Corporation has adopted, then it is indeed a matter in which the public has the deepest interest.

The final answer of the Steel Corporation to such arguments, we presume, is found in the recent statement of President Schwab before the United States Industrial Commission to the effect that the corporation controls 80% of the Lake Superior ore deposits and is rapidly acquiring the rest, while the bulk of the Connellsville coal field is also in its hands. Will this control enable it to do what it pleases with the American iron and steel industry? Can great and necessary gifts of nature be legally monopolized? No principle is more firmly established in the common law than the principle that a monopoly is contrary to the public interest, and that when the fact of its monopoly is established it is subject to public control. The United States Steel Corporation may have the power to wipe out competition, but it will be wise if it exercises its powers with due regard to the public interests.

LETTERS TO THE EDITOR.

The Eccentricity of Object Glasses in Telescopes, In Connection with "Plunging Grades."

Sir: Some time since I noticed, in the correspondence column of your valuable journal, an answer to the query: "What is meant by plunging a grade?" The correspondent took the position that plunging a grade was using a level, or *preferably a transit* with vertical arc, and having driven a stake to grade at each end of the plane by ordinary leveling methods, then set up over one stake, take the height of the instrument on a target-rod and carry it to the stake at the other end of the plane. Next, tilt the telescope until the horizontal cross wire cuts the target. After clamping securely, the line of sight will cut points in a line parallel with and distant from the grade line an amount equal to the height of the instrument.

In my experience I have never been able to do a satisfactory job of leveling with a transit and I have spent considerable time in finding out the reason why. After talking with several makers of scientific instruments I find that a very large percentage of the object glasses manufactured are what they term eccentric; that is, it is impossible to so adjust the instrument that the intersection of the cross wires will cut points in a line which is straight both horizontally and vertically. To obviate this difficulty they insert the glass in the telescope slide in such a position as to throw all the error into the horizontal wire of transits, and into the vertical wire of levels; as transits are used to run lines in a vertical plane and levels are used for running lines in a horizontal plane.

The above-mentioned eccentricity is the cause of the "Caution Notice" inserted in catalogues of engineering instruments regarding the replacing of the object glass back in its cell in the exact position in which it was placed in the factory. In leveling with a transit, equi-distant sights will correct for the above-mentioned eccentricity. The method of plunging a grade does not give a truly uniform grade line as the grade line so run is the chord of an arc, while the true grade line is the arc itself.

Respectfully yours,
S. P. Baird, Assoc. M. Am. Soc. C. E.
Portsmouth Street Railroad and Light Co.,
Portsmouth, O., May 11, 1901.

Diagram for Calculating Size of Beams for Various Locations and Intensities of Concentrated Loads.

Sir: The accompanying diagram shows a method I have found very successful in designing beams and girders having variously placed loads of all sorts and sizes. Its use is especially applicable where the tables given in all steel hand-books for safe loads uniformly distributed on beam and plate and box girders of standard design are available. It has also been found very useful in determining loads which will produce moments equivalent to those produced by moving loads of varying sizes and spacings. All graphical methods for the determination of lengths, thicknesses, etc., of cover plates, etc., are readily applicable to this work as well as some other graphical determinations.

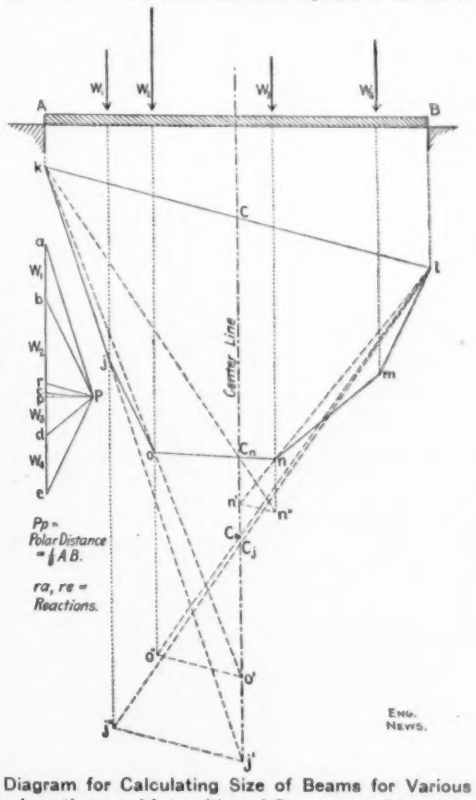


Diagram for Calculating Size of Beams for Various Locations and Intensities of Concentrated Loads.

(Explanation.—Draw beam, A B, loads, W_1, W_2, W_3, etc., and verticals through same. Draw load line, a e. Take polar distance, P p, one-eighth length of beam. Draw stress diagram, P a b c d e, and equilibrium polygon, l m n o j k. Draw vertical through center of beam, CCn. Draw closing line, k l. Draw from end of closing line through corners of equilibrium polygon to center line, l n n', k o o', k j j', etc. Draw from point so found, a line parallel with closing line to meet vertical below corresponding corner of equilibrium polygon, n' n'', o' o'', j' j'', etc. Draw from point so found to other end of closing line, n'' k, o'' l, j'' l, etc. Mark intersection of such lines with center line, Cn, Co, Cj, etc. Center ordinate, CCn, CCo, CCj, etc., gives uniformly distributed load producing same bending moment as given loads at point of beam over corresponding corner of equilibrium polygon. Size of required beam may be taken from tables using length A B, and uniformly distributed load equal to maximum center distance, CCj, measured by scale to which weights are drawn).

Its merits will be readily seen by engineers who need to make use of such a device. Yours very truly,

E. P. Goodrich, Civil Engineer U. S. Navy.
U. S. Navy Yard, Brooklyn, N. Y., April 12, 1901.

A Remarkable Case of Waterfall Pulsations.

Sir: An excellent illustration of the "breathing" of a waterfall is seen in the Oswegatchie River at Ogdensburg, N. Y., where a dam of round timber cribbing creates a fall of about 11 ft., just before the river enters the St. Lawrence.

During the high water of early April there was about 4 ft. of water on the crest of the dam; and while the high stage continued, all Ogdensburg in the vicinity of the dam was vibrating with the rhythm of the waterfall. The Lake Survey office is in the Federal building, a quarter

of a mile from the dam; and here the door rattled, and the transom swung in and out, in a very noticeable way. The pulsation of the door was rapid and continuous, and the transom swung back and forth, in time with it, with the regularity of a clock's pendulum. It is a well-accepted fact in the city, that the rattling of the doors and windows is caused by the waterfall; but to one who meets the fact for the first time, there is a margin of doubt.

To an observer the sunlight was seen to flash rapidly up and down the smooth convex surface of the waterfall with continuous regularity. Since these flashes could be counted and the movements of the door could be counted, their connection was established by demonstrating that the rate of each was the same.

The vibrations were so rapid that attempting to count them ended in confusing the sum; so an electric register, with a stop-watch attached, was used to record the flashes, and an accurate count was secured. At the office, the movements of the door were counted by its tapping against the finger. The rate of vibration of the door and of the waterfall pulsations was thus determined and was found to be 157 to the minute for each.

This "breathing" of the waterfall has been explained as due to the entraining of the air in the space back of the sheet, by the moving water, with inadequate inlets for renewal. Hence a partial vacuum is formed, and the excess of atmospheric pressure on the convex surface of the sheet swings it towards the dam. A partial air supply allows it to swing back again; and thus converts the sheet into a breathing diaphragm. Yet the breathing is all inspiration, no exhalation.

Standing at the end of the dam on a rainy day, watching the water movement, the writer noticed that his umbrella was dancing in time with the swing of the waterfall. Using the umbrella as a feeler, some holes in the cribbing were located, where the air was sucked in so strongly that dry leaves placed near were carried in by the draft; and a pocket handkerchief was drawn in to its full length.

Later, the high water subsided, the flashes on the fall disappeared, and the rattling of the door ceased.

Francis C. Shenehon.

Ogdensburg, N. Y., May 18, 1901.

The Comparative Economy of Embankments and Trestles.

Sir: I am well aware that the information contained in this article is not new; yet it is evident, from my own experience and a careful examination of existing roads, that but little intelligent study has been given to this very important item of railway construction, hence the countless miles of unsightly trestles, a never ending source of care and expense to the railways and a perpetual menace to the lives of the traveling public.

This unfortunate state of affairs may have been due to the convenient and abundant timber along the line of the road, the quick and easy mode of construction, and especially to that erroneous idea of "economy in first cost" which has been the means of wrecking more roads than any other cause.

The question of "Embankment versus Trestle" has always been an important one, and it is doubly so to-day, when the vast forests have moved far backwards and the necessary timber for renewal, which could be obtained a few years ago almost on the right of way, has to be hauled for miles at great expense. With the gradual depreciation of timber in quality and its increase in price, the engineer finds himself, after eight or ten years, confronted with the same problem—an embankment or a renewed trestle at double the first cost?

I am familiar with the great argument of the "economy in first cost" advocate; viz.: that after eight or ten years the company's surplus earnings will be ample to make all renewals permanent and lasting, and that wood will give place to steel and concrete. This might be as true as it is plausible, but in eight or ten years the securities of the roads are generally so watered and manipulated that there is no surplus for betterments, and the evil day is again postponed.

There are cases where wooden trestles are seemingly unavoidable. The wide, swampy approaches to some of our rivers, and the salt marshes which spread along the Southern coast, where solid embankments, on account of the necessary width of waterway, cannot be constructed; yet in many of these locations steel and concrete will be found cheaper in the end. In construction, a temporary trestle is often put in with the intention of filling as soon as the track is carried across, but it generally happens that as soon as traffic begins the timber structure awaits, with its permanent kindred, the day of final renewal.

In order to illustrate the two cases let us take a section of road 100 ft. long and 16 ft. wide and compare the cost of an embankment and a standard trestle of the same length. The following comparison is based on a framed standard trestle, heart timber, pile foundations, with bents 12.5 ft. c. to c., and timber at $25 per M. ft., B. M., in place; and an embankment with 16 ft. roadbed, 1½:1 slopes at 17 cts. per cu. yd.

Applying these figures, we find the cost of an embankment 100 ft. long and 19 ft. high, with crossties and ballast, to be $596.

The cost of a standard trestle of the same length and height, $594.

It is then evident that up to 19 ft. the embankment has no greater first cost than the trestle.

For further illustration we will assume a height of 30 ft. and renew the trestle at periods of ten years, a very long life for the timber generally used in construction at present.

First Cost.

Embankment	$1,250
Trestle	737

After Ten Years.

First cost of embankment, interest and renewal of ties	$2,050
First cost of trestle, interest and renewal, at $30	2,055

After Twenty Years.

First cost of embankment, interest and renewal of ties	$3,280
First cost of trestle, interest and renewal	4,173

Thus we see that at 30 ft. the cost is still in favor of the embankment, and after the first period of ten years the balance is very largely on the side of the earth fill.

In these calculations we have omitted the additional cost of drainage under the embankment. This cost, which would be proportional to length of the fill, would have to be added to our 100-ft. section, and would somewhat reduce the above maximum heights.

I do not pretend to say that there are not many cases where engineers still have to resort to timber trestles; yet I am certain that if they would carefully and intelligently canvas both the present and future cost, there would be fewer of these dangerous and troublesome structures built. A trestle, at best, is but a "dernier ressort."

B. F. Mackall, M. Am. Soc. C. E.

Portsmouth, Va., April 25, 1901.

(Our correspondent might make his comparison still stronger in favor of the earth fill without exaggeration. The risk to trains and the risk of destruction by fire which is inseparable from all wooden trestle construction should be counted against the trestle, for it represents a certain actual annual expense to the company. The fire risk may be closely approximated by the rate of insurance that would have to be paid, and the accident risk may also be approximated. Another item of expense to roads running fast and heavy trains is the slackening of speed when crossing long or high trestles. Still another item to be considered is the cost of inspecting trestles, keeping water barrels filled, protecting piling against the teredo, painting, whitewashing and other items that are necessary in certain cases.—Ed.)

Notes and Queries.

"Constant Reader" is informed that we cannot publish anonymous communications.

TANK LOCOMOTIVE FOR INDIAN STATE RAILWAYS; NORTHWESTERN RY., MUSHKAF-BOLAN DIVISION.

The tank locomotive illustrated in the accompanying half-tone engravings is one of eight recently shipped by the Pittsburg Locomotive Works, of Pittsburg, Pa., for use on the Mushkaf-Balan Division of the Northwestern Railway, India. These engines are almost wholly of American design below the running board, while the boiler—with the exception of the smoke-box—together with the tanks, cab, etc., have been designed to meet British requirements, resulting, as may be seen, in one of the most peculiar appearing locomotives ever turned out of an American works. The engines are built to a gage of 5 ft. 6 ins., and will burn bituminous coal. Some of their special features not included in the list of dimensions and equipment given below are: The use of copper steam and branch pipes; and the employment of gun metal for the exhaust pipe nozzles, slide valves and main axle boxes. The locomotives are equipped with vacuum brakes and the standard couplings used on British railways, and have cylinders at both ends. The exterior fitting which will appear the most unfamiliar to American eyes, however, is undoubtedly the duplex Worthington pump mounted on the front end for feeding the boiler. This pump is necessary in the excessively hot climate of India, where the water becomes too warm in the tanks for injector use. The table which follows gives the other main dimensions and structural features of these Indian locomotives, in our standard form. For the information from which this description has been prepared we are indebted to the Pittsburg Locomotive Works, Pittsburg, Pa.:

Dimensions of Tank Locomotive; Mushkaf-Bolan Division, Northwestern Railway, India.

RUNNING GEAR:	
Driving wheels, No. 8; diameter	4 ft. 3 ins.
Truck wheels, No. 4; diameter	3 " 1 "
Driving wheel centers	Cast steel.
Truck wheels	Steel-tired.
Journals, driving axles	8¼ x 10 ins.
WHEELBASE: Driving, 16 ft.; total engine	34 ft.
WEIGHT IN WORKING ORDER:	
On driving wheels	158,050 lbs.
On truck wheels	56,500 "
Engine total	214,550 "
CYLINDERS: No. 2; diam. and stroke	20 x 26 ins.
VALVE GEAR:	
Ports, steam	16 x 1⅜ ins.; Ports, exhaust. 16 x 3¼ ins.
BOILER: Type	Straight top.
Diam. barrel at front sheet	5 ft. 4 ins.
Thickness, barrel plates	⅜-in.
Horizontal seams	Sextuple riveted; butt joints.
Circumferential seams	Double riveted.
Height from rail to center line	8 ft. 5 ins.
Working steam pressure	180 lbs.
FIREBOX	Copper.
Length, inside	7 ft. 4 ins.; width inside 4 ft. 1⅛ ins.
Kind of crown stays	Radial.
Stay bolts, diameter	1 in.
TUBES: Material	Solid drawn brass; No. 267
Diameter, outside	2 ins.
Length over tube plates	14 ft. 5-16-in.
HEATING SURFACE AND GRATE AREA:	
Heating surface, tubes	1,942 sq. ft.
" " firebox	148 "
" " total	2,090 "
Grate area	30 "

ARE FLOOD HEIGHTS INCREASING IN THE LOWER MISSISSIPPI RIVER?*

By W. J. Hardee,† M. Am. Soc. C. E.

There are to-day few, if any, subjects more perplexing to American engineers than the one of economically controlling the Mississippi River with respect to maintaining adequate depths for low water navigation, providing against the destruction by caving banks of valuable improvements situated in close proximity to its shores, and protecting against overflow the low lands in the valley through which it flows. The subject is, unfortunately, one in which no large number of engineers are directly interested, and it has therefore challenged the attention of not many and the close and devoted study of but few.

No reliable conclusions concerning that part of the subject relating to increasing flood heights can be deduced from a study of the river at any one particular point, or a very short length of it. The investigation should prop-

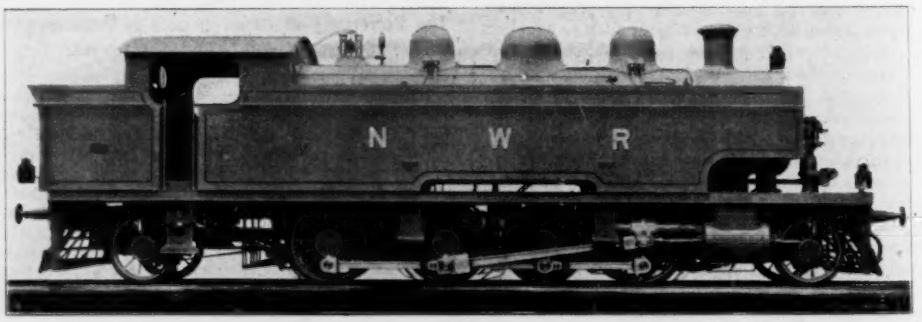


FIG. 1. TANK LOCOMOTIVE FOR MUSHKAF-BOLAN DIVISION, NORTHWESTERN RAILWAY, INDIA.

Pittsburg Locomotive Works, Pittsburg, Pa., Builders.

*Condensed from a paper read before the Louisiana Engineering Society May 13, in discussion of the paper by Mr. L. W. Brown (Eng. News, April 18).

†City Engineer, New Orleans, La.

...rly cover the entire length of the river from Cairo to the ...ulf, for the purpose of disposing of matters of general ...aring and influence; and then there should be con...dered a stretch of river ranging from 100 to 200 miles ...length, throughout which the levee line is continuous ...both banks and no tributary streams occur to exert ...extraneous influence. Consideration of a long length ...river is essential to eliminate local vagaries and afford ...results.

After a careful consideration of the paper before us, ...writer is forced to the conviction that its author un...rtook to discuss his subject with a preconceived ...theory," and in an endeavor to establish the correctness ...that theory he has either failed to make proper re...arch to fully inform himself, or else he has ingeniously ...voided reference to and consideration of such data as ...re properly germane to the subject, reviewing and em...loying only such data as he believed would support his ...theory. He fails, as far as employing data is concerned, ...go beyond the Carrollton gage, using only some con...rovertible data acquired at that gage upon which to base his theory. Where he does venture beyond the Carrollton gage, his conclusions are mere opinions, unsupported by even apparently trustworthy data. The writer has already stated that reliable conclusions cannot be arrived at by a consideration of the river at one point only, as he will later on endeavor to demonstrate. He is so impressed with that belief that on such account alone he would disregard the conclusions reached by the author, no matter how well such conclusions appear to be supported by apparent facts.

The author, fortified with specially selected data, endeavors by fallacious argument to prove that his "theory" is a "condition," predicating his conclusions principally on a comparison of discharge observations measured at the Carrollton, La., Station, propped up by some alleged but unproven facts and some admitted facts so unimportant in effect as not to possess appreciable bearing on the subject. And, having satisfied himself, and ostensibly his readers, that dire calamity threatens the Mississippi River valley in the near future, he exhorts us to employ our best endeavors to discover some avenue which promises relief in a measureable degree, describing a general plan by which he believes adequate relief may be secured.

As the writer cannot admit that a calamity threatens, he will not indulge in a discussion of relief measures, but will confine his attention to a disproval of the conclusions reached by the author. It may not be out of place to at this time remark that the question of utilizing the sediment carried by the waters of the Mississippi River for the upbuilding of the low lands in the alluvial valley is one which is not altogether without merit, but the writer feels that it is a matter which time and circumstance will develop. The cost of the work incidental to such an accomplishment would at this time so far exceed the value of the lands reclaimed as to undoubtedly render the project impracticable.

The population of Holland averages 401 persons to the square mile. Such density of population enhances the value of land to a degree which justifies the large amount of money invested in dikes, extensive drainage canals and gigantic pumping stations to reclaim land and protect it against inundation. In Louisiana the 15 riparian parishes in the alluvial valley, the Parish of Orleans included, average 71 persons to the square mile. In some of the parishes containing the largest areas of very low lands the population per square mile is as small as 7 to 19 persons. Considering the present small value of low lands in the alluvial belt and the large tracts of cheap land available there for cultivation, it may be readily appreciated that our country has not yet reached a stage in its existence at which the expenditure of large sums of money is justified in reclaiming low, ill-drained lands. When such time arrives some method, perhaps along the lines suggested by the author, will be employed to render low lands available for agricultural pursuits.

METHODS USED IN MEASURING DISCHARGE OF THE MISSISSIPPI.

From the writer's knowledge of how discharge measurements are conducted, gained from personal observation, he is confident that not even approximate reliance can be placed on the results obtained. Discharge measurements should be disregarded for purposes other than general approximations. They should never be employed to govern conclusions based on differences shown by a comparison of results obtained at different periods for the same station or close analogy of results obtained at different stations. There are so many opportunities for accidental error which cannot be easily detected that error of result is likely to range as high as 25%. This opinion is shared by many of the officers of the U. S. Engineer Corps, under whose direction discharges of the Mississippi River are measured, as the writer knows from their personal expressions to him.

To illustrate the unreliability of the discharge records quoted by the author, and incidentally for the information of the members of the society who may not be familiar with the detail work embraced in measuring those discharges, the high water depths of the river being as great as 180 ft., the following description of the crude method commonly employed in the past is furnished:

Depths of water were measured with a cotton rope line, weighted with a 7-lb. to 20-lb. lead weight, depending on depth of water and velocity of current; velocities were measured with a Price self-registering current meter. In the early days, before a current meter was invented, velocities were determined by means of surface floats floating over a fixed base line. Both the soundings and velocities were measured from a steam launch of small size, which could be rapidly manoeuvred.

The point at which the discharge is measured is usually designated as a "discharge station." At the station a cross-section of the river is established on a line projected as nearly as practicable at right angles to the general axis of the current. The contour of the submerged portion of the cross-section is developed by a number of soundings taken from a steam launch moving backwards and forwards across the river a number of times. Sub-stations on the cross-section are then established at points marking the angles in the wetted perimeter; to minimize error, in the instance of long planes in the wetted perimeter, the sub-stations are not established further apart than 200 ft.

The depth of the river and the velocity are measured at each sub-station. The depths and mean velocity at adjacent sub-stations are averaged and then multiplied by the distance between the sub-stations, thus determining the discharge for any desired unit of time for that particular division of the cross-section. The several subdivisions are afterwards summed up and the total discharge for the station determined.

On the line of cross-section, on both banks of the river, there are placed, several hundred feet apart, two prominent targets, furnishing a range to guide the boat in taking position on the cross-section. Sub-targets are located along the bank of the river on the upper side of the discharge station, two of which form a range, and so placed that a projected line through them intersects the cross-section line at a sub-station; the targets, of course, are so marked so as to be readily distinguished by the observer on the boat.

The boat is moved to a point slightly above the sub-station to be measured, and when it starts floating with the current the lead is heaved and the boat either worked ahead or backed, as may be necessary, to keep the lead line in vertical position and the boat alongside of each other. As it is difficult after the lead has once touched the bottom to maintain it plumb for any length of time because of deep water and strong current, it is important that it shall be cast just far enough above the line of cross-section to assure it reaching plumb just as the sub-station is reached.

It will be observed that there are two rather difficult points involved in determining correct depths. To begin with, the boat must be skilfully handled and great care taken that it crosses the sub-station at its proper location, which circumstance can only be determined by the boatman through the intersection of the sub-range line and the main cross-section line. This is not so easy to accomplish when it is remembered how easily a small light craft may be influenced by wind and current. The boatman must also take into account the depth of water and velocity to guide him in determining just how far above the station and what position to take with respect thereto to get his boat in shape for casting the lead in order that the boat may cross the sub-station just about the time the lead line becomes plumb.

Each day before sounding is commenced the lead line is soaked for half an hour or so in water, then taken out, stretched and verified. It is always long or short, which difference must be determined, for different depths and applied to the depths measured to correct them.

The writer has personally, on many occasions, directed soundings of the Mississippi River, and on occasions has himself handled the lead line. From his observations and personal experience he is certain that in depths ranging from 100 to 160 ft. of water, flowing at a velocity of from 5 to 7 ft. per second, it is impossible to secure a plumb lead line; there is always a considerable amount of sag throughout the center of the line; just how much cannot be determined, but certainly of sufficient amount to affect the correctness of the sounding.

Before commencing a series of discharge observations the current meter is rated. This is accomplished in slack water by dragging the meter with a boat a number of times over a fixed base. The mean of a number of observations is taken as the fixed relation between a revolution of the meter wheel and a lineal foot. As it would be impossible with the use of one boat and one meter during the day (the time in which a discharge must be measured) to measure the velocity at a number of depths on each sub-station, which should properly be done to secure close results, the inventor, Mr. W. G. Price, then U. S. Assistant Engineer, personally directing the discharge observations at the Carrollton Station, after much study and innumerable observations, fixed for depths of less than 20 ft. 0.4 of the depth below the surface as a point at which the mean velocity occurs, and for depths in excess of 20 ft. 0.6 of the depth below the surface as the point at which the mean velocity occurs.

To one having knowledge of the Mississippi River, who will pause to consider the general turbulence of the flow of its waters, the number of cross currents, boils, eddies, etc., it does not seem reasonable that the mean velocity should really occur at the depths above described. This arbitrary use of a fixed percentage of depth, without allowance for local conditions, at which to measure mean velocities, in the opinion of the writer, contains a considerable element of error.

In measuring a discharge, the first thing done after checking the lead line is to take one sounding at each of the sub-stations. If the sounding corresponds closely with the depth found the preceding day, the boat passes on to the next sub-station; but if any considerable dif-

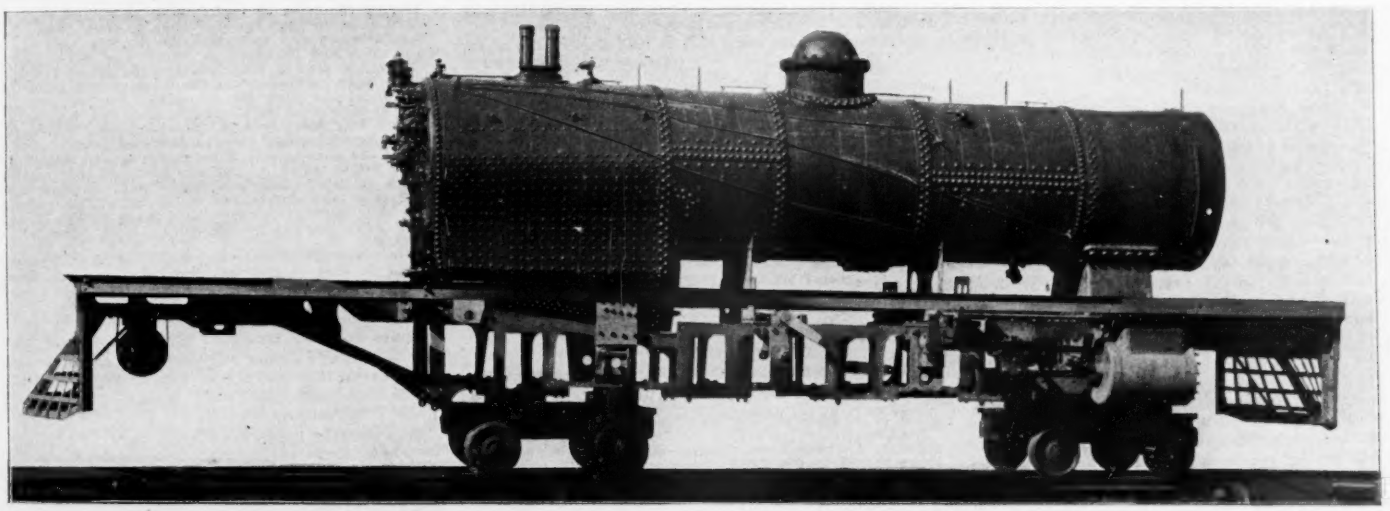


FIG. 2. VIEW SHOWING FRAME AND BOILER OF TANK LOCOMOTIVE FOR INDIAN STATE RAILWAYS.

ference be found a number of additional casts of the lead line are made to verify the sounding and make certain that some change of depth has taken place since the preceding day.

The writer is informed by assistant engineers who have measured discharges at the Carrollton Station that differences as high as 4 ft. have been noted from day to day at a sub-station. Since depths are measured at the sub-stations only, no determination is made of changes, if any, between sub-stations. It will be observed that in this respect there is opportunity for considerable error in the area of that sub-division of the cross-section.

When the depths throughout the discharge section have been determined, the boat takes position in turn at each sub-station. The machinery is worked ahead, just sufficiently strong to overcome the current and maintain the boat in a fixed position; the meter is then lowered to proper depth, and usually is operated for three minutes. The total number of revolutions is registered on a gage on the deck of the boat, the observer closely watching the gage to see that the meter is running evenly. By reducing the total number of revolutions to the equivalent per second and applying the meter rating, the velocity of that sub-station is determined. The opportunities for accidental error in this part of the work of measuring the discharge are not small. The observer must trust to his boatman to keep the boat steady and in proper position, and, as has been stated, it is doubtful that the depth used is the point at which the mean velocity really occurs. Further, the meter is rated but once during a season; its mechanism is delicate and likely at any time to become deranged, thereby affecting all reductions based upon the original rating. It must also be stated that the position of sub-stations is not altered from time to time to meet changes occurring in the bottom of the river.

It would seem almost certain that with such great opportunities as have been mentioned for error to occur, considerable error does occur. The writer is further aware that in the past some of the observers have been almost criminally careless in the performance of their duties. He knows of one observer, whose work forms part of the records of the Mississippi River Commission, who, through an entire series of discharge measurements, never had a lead line cast after the contour of the cross-section was first developed. He contented himself with merely applying the change of gage height to the original depths. A canvass of the records and the inconsistencies found alone proved that the discharge measurements are not reliable within close limits.

In 1880, on June 12 and June 16, Carrollton gage registered 7.6 ft. On the former day the discharge was 581,000 cu. ft. per second, whereas it was only 553,000 cu. ft. per second on the latter day.

Again, in 1851, on July 2 and on July 19, Carrollton gage registered 12.2 ft.; in the former instance the discharge was 805,000 cu. ft. per second, whereas it was 856,000 cu. ft. per second in the latter instance.

Again, in 1890, on March 6 and 7, Carrollton gage registered 15.2 ft.; in the former instance the discharge was 1,175,000 cu. ft. per second, whereas it was only 1,128,000 cu. ft. per second in the latter instance.

The difference in the discharges for the same gage reading may be due to error of measurement, or they may be due to natural changes in the cross-sectional area caused by a rising or a falling river. It does not matter to which cause the difference is chargeable; the fact remains that a discharge determined at a gage reading on a particular day cannot be relied upon as being the same for a similar gage reading at some distant date, a fluctuation of gage height having occurred in the interim.

VARIATIONS IN CROSS-SECTIONS AND CARRYING CAPACITY OF THE CHANNELS.

It will be noted that the author of the paper under discussion rests his case almost entirely on conclusions reached through a comparison of discharge measurements. The writer believes in doing so he has committed a grave error, because not only are the records in that respect faulty, but if they were absolutely correct his case would still remain unproven, since a change in the carrying capacity of the river cannot be established by observations taken at one point only. The discharge is not controlled by the gage height only, but also by the slope existing at the time and place of measurement.

It is a law of hydraulics that, if during a given period over a given length of river, there has been no net loss of cross-section and the elevation of water at the upper end should be increased while at the lower end it remains constant, there will follow increased slope, producing increased velocity and consequently increased discharges.

The writer therefore believes that the author, in seeking to determine whether less discharge occurs at the same of greater gage heights, should have altogether disregarded a comparison of discharges measured at one point only, and should have given his attention to a determination of the changes that have taken place in the carrying capacity of the river.

One of the peculiarities of the Mississippi River is the rapidity with which the area of a given cross-section will vary under the influence of changes in the axis and velocity of the current caused by a rise or fall in the river and a variation in the amount of sediment it is carrying. The records abound with corroboration of that statement.

On a given cross-section the bottom will to-day scour in places and shoal in others. Within the short interval of a few days that result will be found to have been reversed, the abrasions having disappeared and accretions beyond the original elevation having occurred and accretions having disappeared and abrasions below the original elevation having occurred. At times a net increase of cross-sectional area will be noted; at other times a net decrease of cross-sectional area will be noted.

The author of the paper under discussion alleges that the carrying capacity of the river is steadily decreasing, which, in his opinion, forces any given volume of water to attain a higher elevation in passing a given point. A similar allegation has many times been made by many persons.

The Mississippi River Commission, in search of light and truth on the subject, and for its information and guidance, had an investigation made by its principal assistant engineer, Mr. J. A. Ockerson, of the 202.7 miles of river extending from Riverton to Vicksburg. Within that distance 554 cross-sections which were measured during low water in 1881-82 were remeasured during low water in 1894 for purposes of comparison. Members will find Mr. Ockerson's report, entitled "Comparisons of Cross-Section Elements of the Mississippi River," published by the Mississippi River Commission, from whom a copy may be obtained, very interesting. Referring therein to his investigation, Mr. Ockerson says:

> In order to separate the results for pools and crossings, the river has been divided into a series of sections in such a way that the results for the pool sections and bar sections have been summed separately. This is done to detect, if possible, any difference in movement of bed under the two conditions of pool and bar.

After a most careful analysis and review of the subject, in a report covering 29 pages of closely printed matter, Mr. Ockerson expresses the following conclusions:

1. The channel capacity in 1894 was greater than in 1881-82, due to changes above the low water line.

2. The crest of the shoal bars in 1894 were on the whole lower than in 1881-82. This refers to the actual elevation of the bottom and not to the top of water on the bars.

3. The maximum depth of pools was generally less in 1894 than in 1881-82.

4. The thalweg depths were, on the whole, less in 1894 than in 1881-82. That is, a little more than one-half of the length of the river under consideration, and also the average of the sections, shows an elevation of the thalweg, or raising of the bottom. A large percentage of this raising occurs in the pools.

5. The high water bars lying between the medium and bank-full stages have been cut down an average of something over 1 ft.

6. The general fendency seems to be toward a channel more uniform in depth and of greater capacity.

HAS A REDUCTION IN CARRYING CAPACITY OF THE CHANNEL OCCURRED?

The author of the paper under discussion charges diminution in the carrying capacity of the river to the three following principal causes:

1. Construction of levees on lines not calculated to maintain a constant cross-section of that part of the river above the natural bank.

2. Moving back of levees around caving bends, thereby materially increasing the distance to ocean level.

3. Diminution of channel by accretions on the sides and bottom of the river on the apex side of bends without corresponding abrasion on the opposite side.

Referring to the reasons 1 and 2, it may be stated that by actual measurement at the office of the United States Engineers in this city, from Baton Rouge to Carrollton, the average distance the levee line is removed from the natural bank on the west side of the river is 358.68 ft., and 340.26 ft. on the east side, making an aggregate of 698.94 ft. of batture, or foreshore, between the natural bank and the levee line.

It is a well known fact that the flow of the river over the battures, or foreshores, is largely obstructed by eddies, spur levees, vegetation and other obstacles. Suppose, however, that we apply to this width of say 700 ft. an extreme depth of 5 ft. and an extreme velocity of 4 ft. per second, we shall have the small amount of 14,000 cu. ft. of water flowing above and beyond the natural banks. The amount is such an inconsiderable part of a discharge as large as a million or more cubic feet per second as not to be important enough to be considered. In fact the flow over the battures is rarely ever measured and included in the discharge recorded for a station.

It will scarcely be denied that in the three respects cited by the author of the paper before us the length of river from Riverton to Vicksburg possesses more favorable elements for proving the correctness of the author's arguments than does the river from Baton Rouge to Carrollton, a length of 125 miles, which is as great a length above Carrollton as can be reasonably counted on as exerting an influence on the gage at that place.

Between Riverton and Vicksburg the river is made up of a succession of deep bends, with little or no length of straight river between the bends. The levees vary any where from a few hundred feet to five miles or more from the natural bank, as when rebuilt to meet the demands made by destructive caving banks they are retired to a distant location. That length of the river is very variable. The bars build up rapidly and middle ground bars form, splitting the channel and tending to obstruct the flow of the river.

On the other hand, the river between Carrollton and Baton Rouge is fairly straight; there are but few sharp bends and many long lengths of straight river. The levees are quite uniformly removed from the natural bank, there being but one point, Bonnet Carre, at which local conditions force an unusual retirement for a length of about a mile, and the retirement there does not exceed 2,600 ft. Levees which must be retired because of caving banks are rebuilt on locations but a few hundred feet distant. The length of the river is almost constant. The bars do not build up rapidly, and such things as middle ground bars to obstruct the flow of the river are rare and never extensive. Query?—Does it not stand to reason, if in a length of river where all things combine to favor the author's theory the theory fails, that in essentially it must fail when the circumstances are less favorable.

The writer at least believes so, and he is further convinced of the soundness of his opinion that the carrying capacity of that part of the river which might exert an influence on the Carrollton gage has not diminished by a consideration of the conclusions reached by Major Gen. McC. Derby, Corps of Engineers, U. S. Army, in charge of the work of improving the Mississippi River, after careful investigation and analysis.

The writer had the pleasure of assisting in that investigation, which eventuated in a report, dated March 16, 1900, addressed to the Mississippi River Commission, from which the following excerpts are taken:

> Between Red River and New Orleans there are practically no tributaries, and but one small outlet; the length of the river is about constant; the levee system is less variable than elsewhere; and the effect of the tide at the Carrollton gage is so slight that the height of the river may be assumed to be controlled entirely by the stream of water coming from above, unaffected by variations of level, having their origin below.
>
> During the flood of 1897, which broke the high water record at every gage in the Fourth District, I was a good deal surprised and impressed by the fact that the first gage to exceed its previous record was the lowest one, namely, the gage at Fort Jackson; the next was the Carrollton gage, and so on up the river to Red River Landing, where the gage did not exceed its previous record until 16 days after the Carrollton gage had done so.
>
> What was scarcely less surprising was the fact that when the Carrollton gage reached its former maximum (17.45) the gage at Red River Landing still lacked 1.6 ft. of the height which in 1893 had produced that maximum.
>
> Both of these remarkable facts point *at first sight* to the much-looked-for raising of the bed of the lower river with the consequent increase of flood height, which so many have claimed to be the ultimate effect of levee building.
>
> Before attempting to seek the cause of these phenomena it will be well to ascertain first whether they represent merely curious anomalies peculiar to the flood of 1897 or whether they indicate any well established tendency to a change in the regimen of the river.

Tables are then submitted showing the ratio between the Red River Landing and Carrollton gages for all the flood waves that passed the former place at stages of about 45.2, 43.6 and 39.3, respectively. Continuing, Major Derby says:

> More evidence to the same effect could be adduced, but the above seems to be sufficient to establish clearly the proposition that the striking feature of the flood of 1897, under discussion, was not something abnormal, but that, on the contrary, such a change in the regimen of the river has actually taken place that we must now expect that any flood wave passing Red River Landing at a high stage will cause a flood wave at Carrollton a foot or more higher than a flood of the same height at Red River Landing would have caused 15 or 20 years ago.
>
> Now, if this is actually a fact, it must be due to one or more of the three following causes:
>
> 1. A raising of the bed of the river below Carrollton, causing a decrease in the carrying capacity of that portion of the river.
>
> 2. The effect of crevasses and their closure.
>
> 3. An increase of the carrying capacity of the river between Carrollton and Red River Landing.
>
> I will consider each of these possible causes in turn:
>
> 1. Has the bed of the river risen? If the apparent increase in the flood height at Carrollton is due to the filling up of the bed of the river below, it is manifest that such an effect would be proportionately more noticeable in the case of a low flood wave than it would be in great floods. I accordingly submit tables showing the gage readings for many small flood waves which passed both gages well within the banks of the river, a type of waves which usually receives but little attention, but which is in some respect more instructive than the greater waves.
>
> An examination of these tables not only shows that the apparent increase of flood height at Carrollton is not more noticeable at low stages than at high ones, but it reveals, on the contrary, no trace whatever of any such apparent increase.
>
> I conclude that whatever else the apparent increase of flood height at high stages may be due to, it is certainly not caused by a rise of the bed of the river below Carrollton.

Major Derby then also shows that the results observed are not due to crevasses, and continuing, says:

> If we are right in the conclusion that the apparent increase in the relative height of the Carrollton gage is not due to the filling up of the bed of the river below, nor to the effects of crevasses above or below, there must have been an increase in the carrying capacity of the river above Carrollton, the following tables with the others already given, show that this increase in carrying capacity must have taken place at such a height in the bed of the river as to manifest itself only at stages above 27.0 on the Red River Landing gage (highest gage record 50.2).

In the annual report of the Mississippi River Commission for 1899 the surveys made between Red River Landing and Donaldsonville are discussed with results which

are corroborative of the above discussion of the gage readings, the conclusion having been reached that the comparison of the results of all the surveys seems to show conclusively that there had been a general tendency to the permanent enlargement of the stream *above the low-water line*, and the capacity of the river to discharge its flood waters has been more than maintained.

The practical effect of this increase of the carrying capacity of the river between Carrollton and Red River Landing is to diminish the high-water slope, so that a flood wave producing a given height at the Carrollton gage would pass Red River Landing to-day at a level several feet lower than would have been the case 15 or 20 years ago. In other words, since the crevasses have been closed and the levee line maintained with few or no breaks, there has been a notable decrease of flood height at Red River Landing, amounting apparently to 8 ft. or more.

Observe that Major Derby conclusively demonstrates that the carrying capacity of the river has decreased neither above nor below Carrollton; that, on the contrary, there has been a well-defined tendency towards enlargement.

The writer had the only five cross-sections of the river, at the Carrollton Discharge Station, for which reliable records are accessible, platted and the areas below the zero of the gage computed with the following results:

Year.	Gage, height.	Aver. area below zero of gage.
1883	15.4	137,178 sq. ft.
1891	14.8	144,153 "
1893	17.2	151,881 "
1895	2.0	143,750 "
1896	6.1	143,785 "

This table certainly shows no evidence of a progressive decrease in the cross-sectional area, but rather the reverse, as we have in 1895 and 1896 at a low stage a greater area than we had in 1883 at a high stage. But, as has been stated earlier in this paper, the elevation of the bed of the river at any given cross-section varies from day to day, as the river rises or falls, and whether or not the carrying capacity is increasing or decreasing can only be ascertained by determining the net change in a long length of river.

FIXING THE HEIGHT OF LEVEES.

The author of the paper before us says that the government engineers in recommending the "all-levee system" did not take into consideration the serious effect of increasing the elevation of floods, etc. In this he is mistaken. In 1880 when the Mississippi River Commission first came into existence it was without anything like complete and reliable data upon which to base its future operations, nor was it equipped with funds for levee work. From time to time, as far as its funds would permit, it joined the local levee organizations in the general work of restoring and maintaining the continuity of the levee line to a grade 1 ft. higher than the highest previously known water. It was fully recognized at that time and since then, as the transactions of the commission will show, that the grade used was forced by economy; it was deemed advisable, since the levee system would be no more efficient than its weakest lengths, to restore the entire system to some practicable grade rather than to have gaps in the line and some lengths possessing such comparatively extraordinary height as not to render maximum service for years to come. As soon as the continuity of the levee line was re-established and there were funds with which to improve the existing system the commission adopted a provisional grade as the next practicable step to which to advance the height of the levee line. About that time the extension of the levee system along the fronts of previously unleveed immense alluvial basins was undertaken and has since been continued. This extension of the levee system produced a change of flood conditions which made the question of a grade competent to care for future floods very difficult to estimate with precision. The problem would have been more easily solved if only the retention of flood waters between the then existing levees had to be dealt with, but the introduction of the new factor—the leveeing of new basins—made the problem more perplexing.

Future flood heights and ultimate levee grades was the subject of much discussion by the members of the Mississippi River Commission and eminent levee engineers, Captain Townsend of the Army Engineering Corps, and the late Major Wm. Starling, of Greenville, Miss., contributing valuable papers which will be found in the transactions of the American Society of Civil Engineers.

When the levee line had been something like uniformly raised to the first provisional grade and the system had been considerably extended, the greatest flood of record (1897) occurred. From the observations derived from that flood a new grade was adopted which it is confidently believed will meet all future requirements, except probably a most extraordinary coincidence of maximum rain fall in the valley of the Mississippi River and its tributary streams.

The author of the paper under discussion appears ignorant of the facts just related and overlooks the effect which increased flood heights in the upper river, which were anticipated and produced by causes easily comprehended, must exert on flood heights in the lower river.

One of the sound arguments advanced in support of levees lowering flood heights by increasing the carrying capacity of the river, is, in the writer's opinion, contained in the following paragraph in the paper under discussion.

Were the Mississippi River not leveed in or no artificial works constructed along its banks, it would, when rising above its normal banks, overflow and deposit its sediment on the adjacent banks and the surrounding country and as it gradually elevated its banks and the surrounding country, and gradually withheld the waters from overflowing, it would scour a channel of the desired width and depth to convey the volume to the sea level.

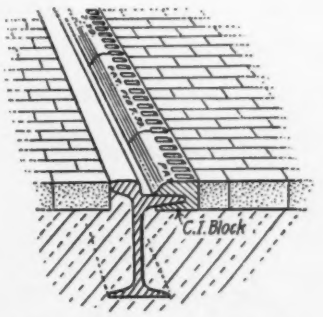
If the river will do what he says it will do, naturally by slow degrees, why should it not do so just as effectively yet more rapidly with the assistance of artificially elevated banks?

The writer is firmly convinced that the levee system is a success; that it is performing its mission well and will continue to do so; that it will in time prove the means of increasing the carrying capacity of the river; and, that floods of a given volume will pass to sea level at lower elevation than formerly.

CONVERTING STEP RAILS TO GROOVED RAILS FOR STREET RAILWAY WORK.

There is a steadily growing feeling in favor of the use of rails with grooved heads for street railway track, in order to make a smoother and more even surface to the street than when rails with step or side-bearing heads are used. In many cases, however, it is practically impossible to introduce the improvement on account of the expense of new rails and reconstruction of the track. To meet this difficulty a special form of cast-iron block has been devised, which is so formed as to fit over the lower part of the rail head and form a groove, the top of the block being level with the rail head and the pavement outside the rail, while the pavement between the rails is relaid level with the blocks. The accompanying cut shows this device applied to a girder rail, with brick paving. It will be seen that the block has a slot in its inner face, to receive the edge of the rail tram, and as the blocks are of cast iron they can be made to fit any form of rail and to give any desired form of groove. The blocks are 12 ins. long, and weigh 8 to 10 lbs. each.

This device has been extensively applied by the Springfield Street Railway Co., of Springfield, Mass., with the approval of the city authorities, after the city had ordered the substitution of grooved girder rails for the old step-head girder rails. There had been considerable complaint as to the danger and discomfort attending the use of streets having the old rails laid in brick paving, but the entire reconstruction of the track would have been very expensive. The paving bricks between the rails were removed and cleaned, and the sand cushion bed on the concrete foundation was increased in depth to bring the bricks level with the pavement outside of the rails. The cast-iron blocks were then put in place, being set in Portland cement mortar, and the paving bricks were then relaid (with the unused edge on top) and grouted with cement. The work was done under contract by Mr. George N. Vaughan, of Springfield, in 1899 and 1900. A favorable report on the work was made by Mr. Mace Moulton, M. Am. Soc. C. E., of Springfield. The device has been in use in that city for 2½ years, and is also in use at Hartford, Conn.



Step-Head Girder Rail Converted into Grooved Rail by the Use of Cast-Iron Blocks.

These blocks are the invention of Mr. Seth J. Buckland, and were patented by him. They are now being introduced by the American Street Railway Paving & Improvement Co., 55 Fuller Building, Springfield, Mass., which sells either the blocks or the right to use them.

PROPOSED COMPENSATION IN KIND FOR WATER DIVERTED FOR THE SUPPLY OF NORWICH, CONN.

By Hill, Quick & Allen.*

The writers have recently made a report to the city of Norwich, Conn.,† in which they have outlined a plan for compensating mill-owners for diverted water by supplying them with stored water in times of drouth, instead of giving money compensation. The plan for a new supply proposes that the city take water from an area of 11.9 square miles draining to Pease Brook, a tributary of the Yantic River. This, with an available storage capacity of about 1,100,000,000 gallons, is estimated to furnish a minimum daily supply of 6,680,000 gallons; or with the present sources, about 8,000,000 gallons per day at all times.

With the increase in consumption that may be expected, the city will require, in the years named, the amounts set underneath the dates, leaving a surplus at each date as specified in the third line, the quantities in each case being in millions of gallons per day:

Year.	1910.	1925.	1940.
Quantity required	2.53	3.45	4.40
Surplus	5.43	4.51	3.56

Below the mouth of Pease Brook there are several important mills operated by water power, as shown by Table I. All the mills, except that of the Falls Co., have steam power.

Data Relating to Mills Below Pease Brook, Affected by the Proposed Diversion of Water.

	Developed HP.	Avail. head, ft.	Drainage, area, sq.mi.	Average working days per an. when dev'd HP. can be had.	Av. days per an. with too little water for econ. use.
Falls Co	900	54	93	206	19
Falls Co.	267	16	93	206	19
Ortrabando Woolen Co.	100	7	89	234	20
Clinton Mills Co.	85	8	88	264	20
Yantic Woolen Co.	175	12	86	213	21
Palmer Bros. Co.	450	22	68	118	36

It has always been taken for granted that the diversion of water from Pease Brook would so militate against these properties as to render its use for a public supply impracticable, and the city, after years of investgation, was on the point of obtaining a supply from another source (Stony Brook), which we have shown would have required supplementing long before the retirement of the bonds issued for its development.

It occurred to us that if the present flow from Pease Brook were released from storage during the nine dryest months of the year (which, by analysis, was found to be the longest period during which the Yantic River, without Pease Brook, could not be safely depended upon for the maximum developed horse power), the mill properties would suffer no damage whatever from the diversion of water for city purposes.

A depletion table was accordingly prepared, which indicated that after the draft to the city should become 4,400,000 gallons per day, or sufficient for the entire estimated supply for the city in 1940, the maximum depletion to be expected would be but 123,700,000 gallons, leaving only 23,000,000 gallons still available. Quoting from our report:

Taking the available supply as 7,960,000 gallons per day, or 388,000,000 cu. ft. per month, and deducting the amount required by the city in 1940, or 216,000,000 cu. ft. per month, the amount available for release to mills is seen to be 172,000,000 cu. ft. This, if released in nine months, would equal 19,100,000 cu. ft. per month. If released in six months, it would equal 28,600,000 cu. ft. per month. The average yield of Pease Brook for these periods in the dryest year may be taken at 12,100,000 cu. ft. for nine months and 4,800,000 cu. ft. per month for six months.

Anticipating, however, the objection that might be urged, namely, that a shortage might occur in any month of the year, the plan proposed by us involved the release of the normal flow of Pease Brook during any month, and by calculating the probable depletion of the reservoir with varying drafts during the dryest series of years, it was found that the city could, under these conditions, rely on a uniform supply of 2,920,000 gallons per day from this source, or 4,200,000 gallons per day in all, which would be adequate until the year 1937.

It only remained to formulate some practicable plan by which the release of the proper volume

*Consulting Engineers, Equitable Building, Baltimore, Md.

†Adopted by the city council on May 6, 1901.

of water to the mills might be made. Quoting again from the report:

It is obvious that under ordinary circumstances only a small part of the yield of the whole watershed from any rainfall would get to the mills in one day, and it is equally obvious that at some seasons of the year the mills would not get it all in a week. It is quite probable that the greater part of all of the run-off from any rainfall would, however, have passed inside of two weeks. We would, therefore, suggest that periods of half months be taken to determine whether any water should be released or not. That is, if the rainfall for any half of a month should be such as to give a flow from the watershed above Fitchville Mill, exclusive of that of Pease Brook, less than the amount required to produce the full power developed at that mill, then the estimated entire flow from the 11.9 square miles of Pease Brook watershed during the same period should be released from the proposed storage reservoir during the next half a month, in constant amounts for each hour that any of the mills run during that period; and if the flow from the watershed above Fitchville Mill, exclusive of that of Pease Brook, during any half of a month should be more than the amount required to produce the full power developed at that mill, no water should be released from the proposed storage reservoir during the next half month. As the estimation of the actual quantity to be released from storage during any of these half month periods would be a laborious and somewhat difficult matter, we give a suggestion as to how this quantity can be easily and quickly determined. The water released can be discharged through a gate and a Venturi meter, and the rate of discharge as registered by the meter can thus be regulated by operating the gate.

In order to determine what proportion of the total flow from the 11.9 miles of Pease Brook watershed this arrangement would leave available for the use of the city under various conditions, and how many years the arrangement could be continued without detriment to the city's interests, we have taken as a basis the monthly rainfall of the last 10 years. As that period included not only the dryest series of years, but also the dryest single year of the last 30, we believe it is fair to assume that the conditions in such a ten-year period would be the worst that would be likely to occur. With that period as a basis, and our estimate of the city's future water consumption, we find that, by this plan of releasing water from storage only when the flow of the Yantic River from the watershed above Fitchville Mill, exclusive of that of Pease Brook, is less than the amount necessary to give the full developed power at that mill, such additions will be made to the amount of water in the proposed storage reservoir during the periods when no water would be released, that it would be 37 years before the estimated city consumption would be great enough, under the worst conditions, to deplete the reservoir to the depth of 14 ft. This depth we have suggested as the limit of available storage only to put the project we recommend on the same conditions as suggested for the other projects. There is no reason why, with a high water elevation of 264 on the proposed reservoir on Pease Brook, it could not be drawn down in an emergency 20 ft., or to about the high water elevation of Fairview reservoir, thus increasing the available storage capacity from 1,100,000 gallons to 1,350,000 gallons, and making it over 50 years that this plan could be continued, under the most unfavorable conditions, before the available storage would be depleted. This limit could be extended many years further by building a diverting conduit and turning into Pease Brook an additional 3.3 square miles of watershed, as shown on the accompanying map. It is within the bounds of possibility that this may never be necessary, as some of the mills on the Yantic River may either have been abandoned or destroyed in 40 years, or such improvements may be made in the use of steam, electric or air power by that time that it will be more economical for the mills to operate continuously by some such power than to operate only a part of the year by water power.

There is no question, then, but that the city could safely agree to release water to the mills on this plan for 50 years to come at least. The only doubt would be as to whether the mill owners would accept such compensation in place of a monetary consideration for the diversion of Pease Brook. We see no reason why they should not accept such an arrangement, as, in addition to its being an entirely feasible and equitable plan, there are other points favorable to its acceptance,

Based on the measured average run-off per square mile from the Sudbury watershed during each month of the past 26 years, we have estimated the probable flow of the Yantic River, without Pease Brook and the present flow of Pease Brook at the site of the proposed dam resulting from 1 in. of rainfall occurring in each month of the year. (See Table II.)

In the application of this method of compensation the rainfall of the preceding one-half month, multiplied by the factor given in the second line of the preceding table for that month, will give the probable rate of flow in the Yantic for the next half month. The amount required above this to furnish 7,200 cu. ft. per minute to the mills may then be released for the ensuing half month up to the normal flow of Pease Brook. This last is found by multiplying the rainfall of the preceding half month by the corresponding factor in the last line of the table.

TABLE II.—Flow in Yantic River and Pease Brook Resulting from a Rainfall of 1-in. in One-Half Month.*
(Cu. ft. per minute.)

Months.	Per cent. run-off.	Flow (sq. miles) 56 on Yantic River.	Flow (sq. miles) 11.9 on Pease Brook
January	50	2,920	620
February	73	4,710	1,000
March	123	7,150	1,500
April	113	6,800	1,440
May	58	3,380	718
June	28	1,680	358
July	8.7	508	108
August	12	700	149
September	13	780	166
October	21	1,220	260
November	37	2,230	473
December	53	3,090	656

*These factors are provisional and subject to correction in the future.

The following three examples will suffice to illustrate the application of the method:

(1) With a rainfall of 2.5 ins. in one-half of May, the flow in Yantic = 2.5 × 3,380 = 8,450 cu. ft. per min. This suffices for all milling purposes, and hence no water would be released from the reservoir for the next two weeks.

(2) With a rainfall of 1 in. in one-half of August, the flow in Yantic = 1 × 700 = 700 cu. ft. per min. Balance required for mills, 7,200 — 700 = 6,500 cu. ft. per min.

Flow in Pease Brook = 1 × 149 = 149 cu. ft. per min. As the normal flow in Pease Brook does not exceed the deficiency, this entire flow of 149 cu. ft. per min. would be released to the mills for the next one-half month.

(3) With a rainfall of 2 ins. in one-half of December, the flow in Yantic = 2 × 3,090 = 6,180 cu. ft. per min. Balance required by mills = 7,200 — 6,180 = 1,020 cu. ft. per min. Flow in Pease Brook, 2 × 656 = 1,312 cu. ft. per min. Balance of Pease Brook flow retained in storage, 292 cu. ft. per min.

In this case, 1,020 cu. ft. per min. would be released during the next half month, giving the mills the full amount required for power.

THE NEW WORKS OF THE EDWARD P. ALLIS CO., AT MILWAUKEE, WIS.

Owing to the growth of its business and the limitations of its present manufacturing plant within the city of Milwaukee, Wis., the Edward P. Allis Co., some months ago resolved upon the establishment of a new additional works at some little distance from the city, where ample land would be available for present needs and future extensions. In the design of the works special attention has been given to the questions of economical handling of materials and product. It is intended to transfer to the new works the manufacture of heavy machinery, including steam engines, electrical machinery, sawmill and rolling mill machinery, sugar and cotton factory machinery, pumping and blowing engines, etc.

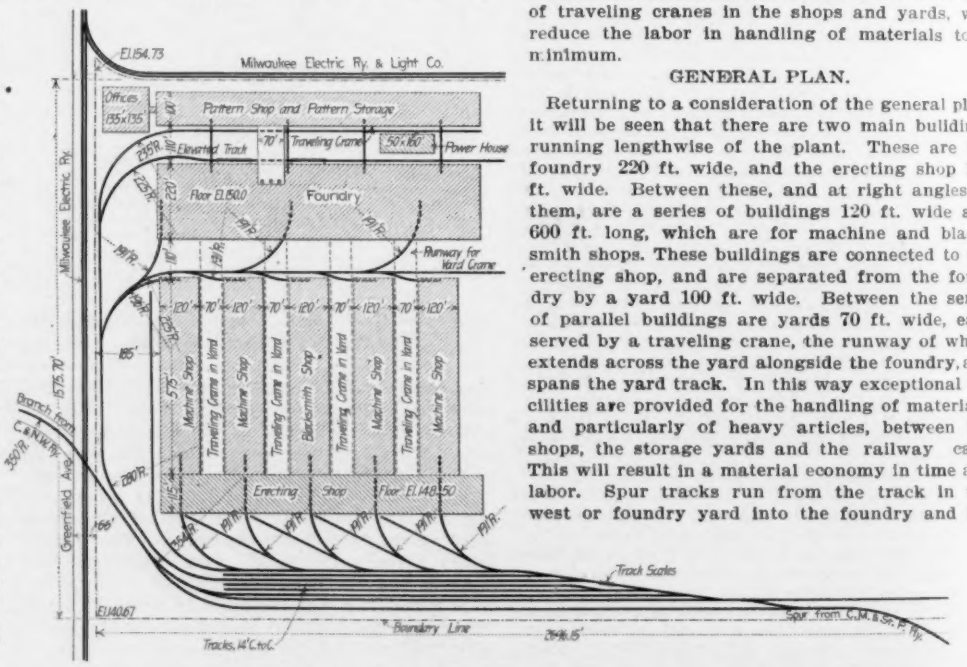


FIG. 1. GENERAL PLAN OF THE NEW WORKS OF THE EDWARD P. ALLIS CO., NEAR MILWAUKEE, WIS.

Edwin Reynolds, M. Am. Soc. M. E., Second Vice-President and Superintendent.

The Riter-Conley Mfg. Co., Pittsburg, Pa., Contractors.

The site selected is at North Greenfield, about four miles from Milwaukee, and is readily accessible by two lines of electric railway from the city, while it is conveniently situated for railroad shipments over both the Chicago & Northwestern Ry. and the Chicago, Milwaukee & St. Paul Ry. A comprehensive plan for the general arrangement of the works has been designed by Mr. Edwin Reynolds, M. Am. Soc. M. E., Second Vice-President and Superintendent of the company. The arrangement is such as to admit of the immediate construction of a portion of the plant which will be complete in itself, and will yet admit of almost indefinte extension to meet future growth of the business, without interference with the work in the completed portion.

A general plan of the works is shown in Fig. 1, reproduced from a drawing furnished us by Mr. Reynolds. The tract of land purchased is 2,807 ft. long and 1,575 ft. wide. The south end is on Greenfield Ave., and the north end on the right of way of the Chicago, Milwaukee & St. Paul Ry., while along the west side runs the Waukesha line of the Milwaukee electric railway. About half a mile to the south is the Chicago & Northwestern Ry., from which a line will be built to the works, as shown on the plan. In this connection it will be of interest to consider the railway yard laid out on the east side of the works. A through track, 1 (outside the company's fence), will connect the spurs from the two railways, and incoming cars will be put on tracks 1, 2, or 3, ready for handling by the company's switch engines as required. In distributing these cars, they will be run out onto the main ladder track, and sent over tracks 6 or 8 to any part of the plant, passing over the track scales on their way. Outgoing cars will be brought onto the ladder track, passing over the track scales, and then put onto storage tracks 4, 5 or 7, whence they will be taken at convenient times to the main line connections. These yard tracks are 14 ft. c. to c. All parts of the works will be served by standard gage tracks, with spurs into all the shops, as shown. This arrangement, in combination with the extensive use of traveling cranes in the shops and yards, will reduce the labor in handling of materials to a minimum.

GENERAL PLAN.

Returning to a consideration of the general plan, it will be seen that there are two main buildings running lengthwise of the plant. These are the foundry 220 ft. wide, and the erecting shop 115 ft. wide. Between these, and at right angles to them, are a series of buildings 120 ft. wide and 600 ft. long, which are for machine and blacksmith shops. These buildings are connected to the erecting shop, and are separated from the foundry by a yard 100 ft. wide. Between the series of parallel buildings are yards 70 ft. wide, each served by a traveling crane, the runway of which extends across the yard alongside the foundry, and spans the yard track. In this way exceptional facilities are provided for the handling of materials, and particularly of heavy articles, between the shops, the storage yards and the railway cars. This will result in a material economy in time and labor. Spur tracks run from the track in the west or foundry yard into the foundry and the machine shops. On the east side, spur tracks from the yard traverse the erecting shop and enter the ends of the machine shops. It will readily be seen that this arrangement admits of unlimited extension. The parallel foundry and erecting shop can be lengthened, and additional lateral buildings for machine and blacksmith shops can be erected between them, as desired.

Along the west side of the plant, and parallel with the foundry, will be a pattern shop and pattern storage house 100 ft. wide. Between this and the foundry will be a power-house, 50 × 160 ft. Running along the west side of the foundry will be an elevated track serving the two sand sheds, 22 × 100 ft., and the charging platform of the cupolas, 65 × 70 ft. A traveling crane will cross the 110-ft. yard between the foundry and the pattern shop. At the southwest corner of the plant will be an office building 135 ft. square, with large drafting rooms. The water supply will be obtained from wells on the company's land, and the buildings will be lighted by electricity and heated by steam. The machinery and tools will be in the main operated by electricity, the current being distributed from the plant in the power-house.

BUILDINGS.

The plant will not be built all at once, but the first part to be erected will include the erecting shop (for a length of 872 ft.), and the five lateral buildings shown on the plan, Fig. 1. The four outer buildings will be machine shops, while the middle one will be a blacksmith shop. The general designs for the building construction were

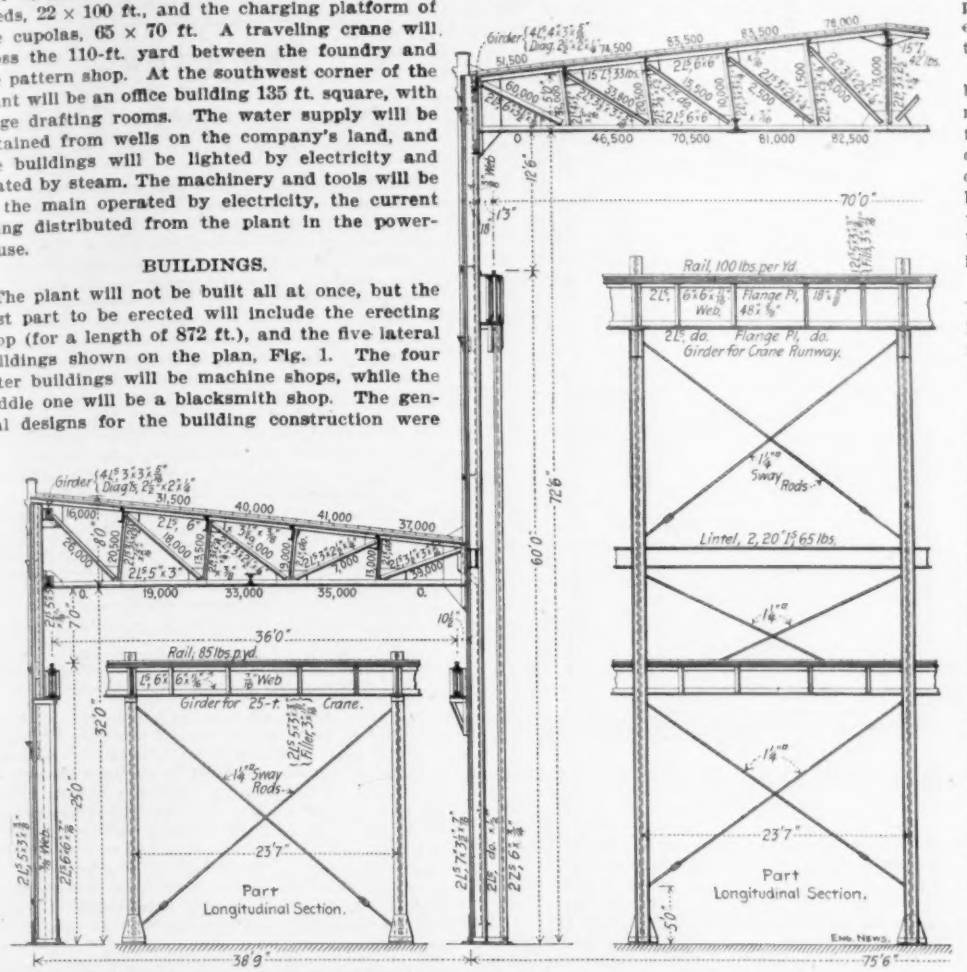


FIG. 2. HALF CROSS-SECTION OF ERECTING SHOP FOR NEW WORKS OF E. P. ALLIS CO.

prepared by Mr. Edwin Reynolds, as already noted. The contract for the structural work and its erection has been let to the Riter-Conley Mfg. Co., of Pittsburg Pa., to whom we are indebted for plans and other information.

The erecting shop will be a single story building, with walls about 80 ft. high for the main portion and 42 ft. for the side portion or annex. The other buildings will be one-story high in the central portion and two stories at the sides, the walls being 45 ft. high. The buildings will be of steel frame construction with brick curtain walls and steel roof trusses. The trusses will carry steel purlins and jack rafters, with a sheathing of 2-in. plank covered with a tar and gravel roofing composition. The roofs will slope to gutters which come inside the buildings, the gutters and eaves pipes being left fully exposed, in order to allow the warm air of the shops to surround them. This is one of the special features of the design. The gutters and conductors are of copper, except that the lower end of the conductor pipes is made of wrought iron for a height of 10 ft. in order to prevent their being bent or broken by the handling of materials in the shop. The foundations will be of piling, with concrete pedestals for the steel columns. The structural work has been designed with a factor of safety of four, based on maximum loads, which are as follows: Loading, 20 lbs.; wind and snow pressure on roof, 30 lbs.; wind pressure (lateral), 20 lbs.

ERECTING SHOP.—This building will be 120 ft. wide and 875 ft. long. The main portion, 72 ft. 6 ins. wide inside, will have a clear height of 72 ft. 6 ins. to the roof trusses, and 60 ft. to the rails for the traveling cranes. The outer portion, 38 ft. wide inside, will have a height of 32 ft. to the roof trusses and 25 ft. to the rails for the traveling cranes. The columns are of H section, with shoes anchored to concrete pedestals. On the inner face of each column is an auxiliary column to carry the crane runway. The outer columns have ⅜-in. web plates 26 ins. wide to the level of the runway girder, and 12 ins. wide above this. A horizontal line of lintel beams extends between the main columns at a height of about 34 ft., each lintel being composed of two 20-in. 60-lb. I-beams.

The main portion of the building will be served by a 75-ton electric traveling crane, 70 ft. span between the runway rails, which are 100-lb. T-rails carried on box girders. The side portion of the building will be served by a 25-ton electric traveling crane of 36-ft. span, running on 85-lb. rails on plate girder runways. These plate girders are carried by the wide lower portion of the outer columns and by brackets on the inner columns.

The roof trusses are comparatively shallow, and are of riveted construction. The purlins are 15-in. channels, but the ridge purlin of the main roof is a 15-in. I-beam. The strain sheets and construction details of these roofs are shown in Fig. 2. There is no monitor roof above the main roof, ventilation being provided for by the four rows of windows, and light being provided by means of the windows and fixed wire-glass skylights in the roof surface.

The exterior will be of buff Milwaukee brick with simple ornamental light terra-cotta work over the windows and along the cornices. The surface will be broken up by piers occurring at the columns, and by projecting belt courses and cornices formed in the brickwork, relieved by brick corbels. There will be ample window area, and all the windows will have movable balanced sashes. Large doorways are provided, and are fitted with double-swinging wooden doors. Fig. 3 shows a gable end and part of a side elevation.

MACHINE SHOPS AND BLACKSMITH SHOP.—These five buildings are identical in design, and the following description of one will apply to them all. There are four rows of columns, carrying a central span of 70 ft., and two side spans of 25½ ft. The construction is shown in Fig. 4. Up to the level of the girders for the runways of the traveling cranes, the web plates of the columns are 26 ins. wide, but above this the web plates are only 12 ins. wide. On the outer side of each row of main columns is a longitudinal trussed girder, 6 ft. deep.

The central bay of the building will be served by a 40-ton electric traveling crane. The track rails weigh 85 lbs. per yd., and are carried on the flange plates of box girders resting on bearings on the wide lower portions of the columns. Each of the yards between the buildings will be spanned by a similar outdoor crane, the runway girders of which are carried by the outer columns of the buildings in the same way as described for the inside cranes.

Midway between the main columns of the outer walls are intermediate columns which do not support the crane runway, but carry the intermediate girders of the upper floor. These make the outer panels 12 ft. 6 ins. long, c. to c., instead of 25 ft.

The side bays of the building, which are intended for the smaller tools, have two stories, the lower one 18 ft. and the upper one 14 ft. 8 ins. high in the clear. The upper floor is designed to carry a load of 350 lbs. per sq. ft., while the girders and columns are designed for about two-thirds of this load. The main columns in this building are 25 ft. apart, but in order to lighten the floor beams, these beams are spaced 12 ft. 6 ins. apart, the outer ends being supported by the intermediate columns above described, while the inner ends are riveted to heavy connection-plates in the longitudinal girders between the inner main columns. The roof trusses are spaced 25 ft. apart, as in the central part of the building. The close spacing of the floor beams gives good support for the line shafting of the main floor, the hangers being attached to the bottom flanges. The line shafting for the upper floor is supported by the eave girder of the main span, the top of this girder being held rigidly in place by the jack rafters of the roof and the bottom being stiffened for lateral strains by the 15-in. channel shown on the drawing.

The plate-girder floor beams carry nine lines of floor stringers. On top of each joist is a wooden spiking strip, and to these strips are nailed the flooring, which consists of a lower course of 2-in. pine planks laid transversely, and an upper or wearing course of 1-in. maple planks, laid diagonally.

The roof trusses are set between the tops of the columns, and are riveted to them by means of end

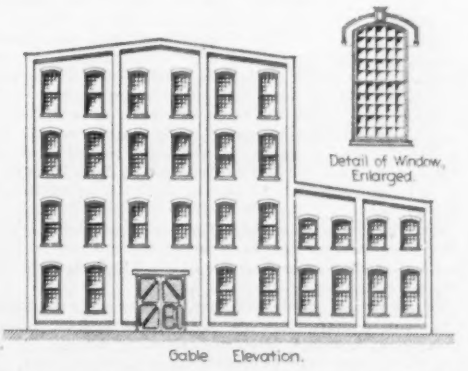


Fig. 3. Gable Elevation of Erecting Shop with Detail of Window.

gusset plates and angles, making a very rigid and substantial construction, especially for lateral strains. The main trusses over the central bay, are of very similar design to the roof trusses of the erecting shop, but have a shallow triangular monitor roof over the four central panels of the truss. In this monitor roof is a skylight of ¼-in. glass, while the sides of the main roof are covered with plank sheathing and a tar and gravel roofing composition. This arrangement is somewhat unusual, there being no vertical sides to the monitor roof. The skylight trusses are 12 ft. 6 ins. c. to c., in order to reduce the section of the channel purlins under the skylights, so that less

light would be obstructed. The roof trusses of the side spans are of somewhat different design, and carry a roof pitching towards the inside. All purlins are steel channels, with the exception of the ridge purlins of the main trusses and the ridge and side purlins of the monitor roof trusses, all of which are I-beams. The trusses are made with riveted conections throughout, and have large

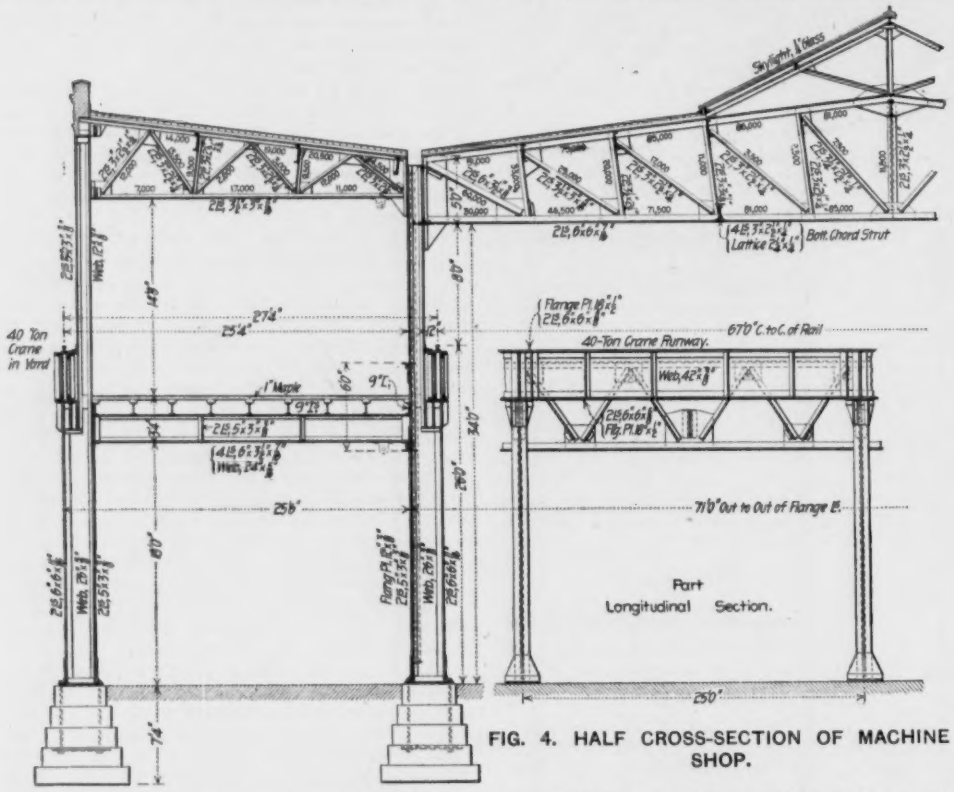


FIG. 4. HALF CROSS-SECTION OF MACHINE SHOP.

gusset or connection plates at all panel points, as well as broad gussets at the ends, where the trusses are riveted to the columns.

The architectural treatment is like that of the erecting shop.

NOTES ON INSTRUMENT TRIPODS.*

By John H. Harden.†

In the valuable paper of Mr. Dunbar D. Scott and its varied discussion on the evolution of mine surveying instruments, the tripod head has not received the attention it merits. During the last fifty years this very necessary adjunct to the surveyor's instrument has been much improved. The legs are of better construction, and the devices for laterally moving the instrument over the station point and for quick leveling, without the use of the screws, have given to the instrument fitted with the modern tripod head the same facilities possessed by the old-fashioned ball-and-socket, with more perfect accuracy, not attainable in the latter, while saving from 30 to 50% of the time required for setting the instrument over a station.

For the purpose of extending the discussion to this important part of the instrument the subject is here treated under the two divisions of the tripod legs and the tripod head.

Tripod legs of wood have been made of different forms and cross-section, designed to suit surface or underground surveying of varied character, including:

1. The round leg, of equal diameter throughout its length, with metallic screw joints in the middle, reducing the height of the instrument one-half, when required, as in the leg of the "Hedley" dial. This form of leg has no less than nine joints, wood and metal coming together; it was never a firm, certainly not a durable support, owing to the contraction of the wood within the metal; and the attachment to the head gave an uneven movement to the joint.

2. The round leg, larger in diameter in the middle of its length, fitting between plates in the tripod head. It is defective at this joint and its movement is uneven.

3. The angular section leg (120°), in which three legs combined form, when closed, one compact round leg, sectionally larger in the middle of its length, very convenient and easy to handle. The joint with the head is metallic, insuring a uniform movement. The rigid fastening of the metal to the wood with wooden screws is not durable, owing to unequal expansion and contraction of the parts.

4. The lattice or built leg, solid for a short part of the lower length, spread to receive the joint at the head, and with one or all legs adjustable to the height of the mine or contour of the surface. This, the modern form of leg, is more nearly perfect, and gives a firmer support, without being heavier, than any other leg designed. All its parts adjust themselves and clamp together firmly, to make decidedly the best form of tripod leg for all classes of instrumental work in the field or mine.

The tripod head, connecting the instrument with the legs, was, in its earliest inception, a rigid piece of mechanism, with ball-and-socket or screws (3 or 4) for leveling the instrument after the legs had been manipulated to obtain the exact position, as nearly level as possible, over a station point—an operation occupying much time and strategy, according to the nature of the ground.

In the year 1858, Mr. William J. Young, of Philadelphia, invented an improvement in tripod heads, known as the "shifting head." This was a decided improvement; for it enabled the surveyor to dispense, in a large degree, with the process of moving or depressing one or other of the legs to bring the instrument exactly over the station point. This exactness is attained by moving the instrument laterally on the head, by means of the shifting plate, within the limits designed—usually about 1 in.

In 1877, Mr. Daniel Hoffman, of Philadelphia, introduced his improved tripod head, with a quick-leveling device, together with the Young shifting device. We now have a tripod head with all facilities for adjusting the instrument over a station, approximately leveling it without using the screws, and requiring for the whole operation from 30 to 50% less time. The two devices mentioned, with the lattice-built legs, make a tripod fully equal to the other parts of a modern surveying instrument.

Actual practice is the true test. I have used these devices on all my instruments during twenty years, and have proved them to be mechanically correct in principle, and to work well in practice. Never on any occasion has dust affected the smooth working of the upper half-ball, described by Mr. Lyman; and the tripods made by Heller and Brightly in 1879 are as perfect in their movement as they were the day they left the hands of the maker.

It is true that the height of the instrument is somewhat increased, though not to such an extent as to destroy its stability, firmness or usefulness. It is also true that the approximate parallelism of the parallel plates of the tripod may be maintained, without such a device, merely by careful setting of the tripod, with or without extensible legs. This careful setting of the tripod legs, and the time required for doing it, is what is avoided in the use of the Hoffman and Young devices, which give to the modern tripod head its superiority. In proof of this the devices have had their imitators; the Young shifting device having been imitated by Draper and others, and the Hoffman quick-leveling device by Young, Gurley and others.

In the suit of Hoffman vs. Young for infringement, decided by Judge Butler in favor of Hoffman, such eminent engineers as the late Eckley B. Coxe, Prof. Lewis M. Haupt, D. McN. Stauffer, the late Thomas Shaw and others, gave evidence in favor of the device as a valuable addition to the tripod head, before unknown to them. The Hoffman invention, patented in England, has been largely applied to both new and old instruments by John Hall & Son, Derby.

*A paper read at the Richmond meeting of the American Institute of Mining Engineers.

†Phoenixville, Arizona.

BOOK REVIEWS.

THE PROGRESS OF INVENTION IN THE NINETEENTH CENTURY.—By Edward W. Byrn. New York: Munn & Co. Cloth; 7 × 10 ins.; pp. 476; 300 illustrations. $3.

This book presents a large amount of interesting and useful information in a readable manner. After a preliminary review and a chronological table of inventions, there are seven chapters on various applications of electricity; then a chapter, each on the steam engine, steam railway and steam navigation. The work continues with such leading subjects as printing, the typewriter, sewing machine, and photography. There is a separate chapter on civil engineering and also on fire arms and explosives. The many illustrations are generally serviceable. The chapter on "Medicine, Surgery and Sanitation" is weak in the latter particular. Nearly all that is said under sanitation relates to house plumbing and repeats with emphasis the old story about "germ-laden and disease-breeding gases from the sewer." The uninformed reader might get the idea, from this portion of the book, that the chief progress in sanitary science during the past century had been in the matter of patented water closet and bath appliances, traps and non-siphoning devices for the latter. This section illustrates the tendency of the book to be superficial at many points. Still, in judging its merits, one must remember that it is, primarily, a popular account of the progress of inventions, based largely on patent office records. As such, the book may be classed as a success.

MUNICIPAL PUBLIC WORKS.—An Elementary Manual of Municipal Engineering. By Ernest McCullough, C. E. Lewiston, Ida.: The author. Paper; 6 × 9 ins.; pp. 153; illustrations. 50 cts.

This is a second and enlarged edition of a book first published in 1894. While designed primarily for the officials of small cities and towns, it is full of information of value to engineers employed by the same class of municipalities. In addition, it contains a number of suggestions, in the chapters on "Plans and Surveys" and "The City Engineer," which might prove useful to any city engineer. The other chapters deal with streets, sewerage, water supply, street lighting, fire protection and municipal ownership. One of the best features of the book is its hints on showing inexperienced but well-meaning councilmen and town trustees the value of good engineering services.

INVENTOR'S MANUAL.—How to work a patent to make it pay. By an experienced and successful inventor. New revised and enlarged edition. New York: Norman W. Henley & Co. 5 × 7 ins.; cloth; pp. 115. Price $1.

The proper advice to give inventors of the sort for whom this book is written is, "Don't." The advice contained in this book is for the most part of the same sort as that found in the advertising literature distributed by a certain class of patent solicitors. The inventor who has one of these publications and a copy of the Patent Office "Rules of Practice," which is sent free by the Patent Office on request, will find very little new or useful matter in this book.

THE PRINCIPLES AND PRACTICE OF LINEAR PERSPECTIVE, DEVELOPED ALONG ORIGINAL LINES.—Being a practical hand-book for architects, civil and mechanical engineers and designers, engravers, and for draftsmen engaged in all the industrial arts. By Herman T. C. Krauss, C. E. New York: Norman W. Henley & Co. Boards; oblong; 15¾ × 11¾ ins.; pp. 53; 14 plates of practical examples. Price, $2.50.

The plates used by the author are novel, and well illustrate the principles of linear and geometric perspective. The explanatory text, however, while sufficiently clear to the expert, is hardly full enough to satisfy the novices in some of its details. But a little study will bring out the purpose of the writer; and in a number of cases the presentation of the subject is superior to the usual treatise on linear perspective, inasmuch as it demonstrates the value of preliminary sketches in working out the more intricate problems in perspective.

ELABORATION DES METAUX DERIVES DU FER. FOYERS METALLURGIQUES.—Par L. Gages, Capitaine d'artillerie. Paris: Gauthier-Villars, Quai des Grands-Augustins 55. Paper; 4⅝ × 7⅝ ins.; pp. 160; illustrated. 2.50 francs.

In this work the author treats of the various types of furnaces used in the reduction of iron ores. In his introduction he discusses natural and artificial fuels and their proper combustion. He follows this with a study of the various types of furnaces, including those in which the fuel is in contact with the ore and those in which it is separated from the material under treatment. In a separate chapter he takes in gas furnaces of the Siemens type and those derived from this type. The author finally examines the composition of and the duties performed by the refractory materials employed in the furnaces referred to.